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GROUP OF STATUARY, REPRESENTING THE INTERNATIONAL POSTAL UNION, ON THE NEW POST OFFICE GENERAL, AT HANOVER, GERMANY.

THE annexed cut shows a representation of the group of statuary, "The International Postal Union," on the new Post Office General, at Hanover. The group is about 20 feet high, and consists of a globe about 6½ feet in diameter, resting on and partly within a base 19 inches high. A winged female figure, about 11½ feet high, representing the International Postal Union, stands on the globe and has one arm raised and pointing out into the wide world, and the other hand holds a number of letters. Two winged genii are at the sides of the globe, one of them holding telegraph poles and thunderbolts, the other holding a torch and a wheel to express the close relations of the railroads and telegraphy to the mail service. The group is cast in zinc, and was designed by Mr. W. Albermann, in Cologne, and executed by Richard Rocholl's successors, the well-known zinc founders of Cologne.

POSTAL UNION STATUARY, HANOVER, GERMANY

CEMENT-BETON AND ARTIFICIAL STONE.

AT an assembly of German cement makers, Von Froideville made a report, which was published in the *Thonindustrie Zeitung*, in which he said:

A good cement does not crack, and even in a northern climate is able to resist the weather, supposing it has been properly mixed. If too much water has been used, so that a glassy crust forms on the surface, and the whole mass is not homogeneous, the cement checks or cracks, and as soon as hair cracks appear, moisture enters and the frost completely destroys it. A second fault is when the cement strikes out, which it ought not to do. Cement can be colored nicely and permanently with suitable colors, but quite a good deal of color is necessary if it is required to entirely hide the natural color of the cement and give it the exact color desired. The addition of a coloring to cement makes it more friable and softer, so that it takes comparatively more cement than without the color. Cement is only just coming to be understood in practice; but, on the other hand, architects are too distrustful of artificial stone.

For several years artificial stones for curbstones and street gutters have been made at Potsdam, and have lasted well. The gutter stones are very cleanly and neat, and the fear that frosts and the pressure of the earth on both sides would destroy them has proved unfounded.

Granite, when broken up fine, imparts to cement a very considerable strength similar to gravel, but the pieces of stone, being heavier, settle and interfere with its manufacture. On the other hand, the addition of granite to cement without any sand makes an excellent material. In the gymnasium at Potsdam are two pillars made in this way, which support not only a cross-vaulted arch, but also bear the pillars that extend to the upper story.

When marble is combined with cement without the addition of any sand, blocks are obtained of such strength that they are capable of receiving a fine polish, but cement must first assume the strength of stone. The problem was presented of building stairs with steps 40 in. long, set into the masonry 8 in. at one end, each step having a height of 6½ in., and a total width of 14½ in. Experimental blocks were prepared, and at the end of six weeks four steps were put up for trial. Railroad iron was piled up on the steps, and the weight gradually increased until it reached 5,940 pounds. The steps held out, but no more could be put on because the masonry began to yield. The load was left on the steps for three days and nights without any injury. The steps subsequently remained unaffected. By adding pieces of marble to the cement different kinds of stone were imitated, with a saving of expense equal to nearly one-half the cost of real granite work.

A considerable quantity of cement is used for the flooring of terrace work. The manufacture of old Roman marble mosaics for parquettes and floors has rested many centuries, and has only recently been revived. The Italians make a ground bed or beton stratum from puzzolana, or hydraulic lime, and pieces of brick, and lay the mass also in brick-dust. Portland cement answers much better than these for joining the pieces of marble and such like, and can also be employed for mosaic plates and tiles.

Cement-beton—coarse gravel with cement below, fine sand with cement on top—is a pleasant and durable material used more and more every year for sidewalks and such like purposes. But many other things have been made of it—building objects, floor and cellar coverings, vaults, cattle-cribs, stables, and even whole houses, as well as a series of bridges, that are both good and cheap.

At the meeting referred to, where this report was made, one firm in Amœneburg, near Bilbrich, exhibited photographs of a bridge which they had made for the Düsseldorf exhibition, while a Frankfort firm showed the plans and pictures of another beton bridge, also at Düsseldorf. It was planned by Loehr, and the arch had a breadth of 73 ft. and a spring of only 71 in. The thickness of the arch at the counterfort was 14 in., and 18 in. at the top. The arch was constructed after the counterfort was done, April 14, 1881, by four cement workers and twenty hod carriers and helpers in *eight hours*. It was tested, May 25, by a one-sided load on half the arch of 400 kilos per square meter, or about 80 pounds per square foot, without injury. It was then thrown open to the public, and was in use during the whole time of the exhibition.

Another firm had erected two large two-story farmhouses in Lauenburg, each 166 ft. long and 76 ft. wide, with an average height of 25 ft., all of beton. The walls were 8 in. thick on the first floor, strengthened every 10 ft. or 15 ft. with an extra thickness of 4 in more, while the second floor had walls of only about 7 in. in thickness. The mixture employed consisted of one part of cement, two parts of sand, and six parts of gravel. The work occupied two months.

ZUNIS WORSHIPING AT THE SUNRISE SEA.

THE religious ceremony for which the party of Zuni Indians came to the East, under the leadership of Mr. Frank H. Cushing, of the Smithsonian Institution, took place in Boston harbor, March 28. A large party went out from Boston to witness the ceremony, which may be fairly considered the most remarkable that has occurred in that region since the landing of the Pilgrim Fathers.

The Zunis and the rest crossed over the harbor to Deer Island, in a steamer furnished by the city mayor. As soon as the Zunis boarded the vessel they went, with Mr. Curtis, to the pilot house, whence they looked upon the bay and scattered flour upon the winds, chanting meanwhile a sing song prayer.

Two tents had been pitched for them on the shore of the Ocean of Sunrise. Into the larger of these tents the Zunis and Mr. Cushing retired to prepare themselves for the ceremonies. When they emerged upon the sand they betook themselves with solemn step to the shore, followed by the crowd.

The Indians bore upon their backs their shields and weapons of war, and in their hands carried hollow gourds and glass vases with which to take up the sacred water.

Arrived at the water's edge they squatted on the rocks and began to chant a prayer in a low monotone, and as they chanted they scattered meal from their pouches upon the sea, in four different directions, to propitiate, as the *Sun* reporter says, the Gods of the North and of the South, of the upper and of the lower regions, the Mother of the Ocean and the Father of the World. The symbol of this strewn meal is of a road or path which the priests mark out with it, signifying a request that the paths in life of the suppliants and their children may be "finished," to use the Zuni expression, or drawn out to a distant end, as we might say.

The Indians were much pleased with the rising tide, considering it a mark of especial favor on the part of the gods of the sea.

When they came ashore out of the water they formed a circle, sitting close together, and smoked sacred cigarettes made of cane filled with consecrated tobacco. As they smoked they prayed and blew the smoke among the feathers of the prayer sticks they carried. Then they cast the prayer

sticks into the waves. Then the two head chiefs waded back into the icy waters and filled their gourds and vases, and went to the tents. On their way they whirled into the air sticks at the end of thongs, making a whizzing noise. The gods were thus informed that the ceremony was finished. Another song was chanted, reciting the good expected to result from the act of worship. The sacred meal was four times scattered westward, the direction they must take in returning to their own land. In addition to the gourds and vases, the Indians took back seven large demijohns of sea water, which will be consecrated after their return.

The concluding ceremony was the initiation of Mr. Cushing into the highest order of the bow. He was taken to the shore, stripped of his headdress, was baptized, and his hands were washed. Incantations were chanted meanwhile, and then the chiefs embraced him. This makes Mr. Cushing in every sense a Zuni. On his return, however, he must subject himself to several trying ordeals, one test being a fast of four days and nights. He will then be permitted to read the secret history of the tribe, which is expected to throw much light upon Indian history in America.

[CONTINUED from SCIENTIFIC AMERICAN SUPPLEMENT, No. 326, page 5231.]

ON WARMING AND VENTILATING OCCUPIED BUILDINGS.

By ARTHUR MORIN, Director of the Conservatory of Arts and Trades, Paris.*

HALLS OF ASSEMBLY AND LECTURE-ROOMS.

120. THESE places of temporary resort, where there is often more than one person to every square foot of floor-surface, should be ventilated at the rate of 1,000 cubic feet of air an hour to each person.

The arrangements which I have adopted for the main lecture-hall of the Conservatory of Arts and Trades, and of which the satisfactory results have been seen every day for five years, appear to me worthy of imitation.

The foul air is drawn off through openings in the risers behind the feet of the auditors, and their total clear area for the passage of the air—deduction being made for the solid portions of the grating, if there are any—should be calculated so that the air will only attain a velocity of 28 or 30 inches a second. This surface also should be distributed as uniformly as possible among the steps.

The basement under the lecture-room, kept as clear as possible, should communicate with a ventilating gallery, placed underground, or at the ground-floor level if possible, the sectional area of which should be calculated so that the velocity of the air shall not be greater than 4 feet a second.

This gallery should terminate in a ventilating-chimney, the mean section of which should be determined on the condition that the velocity of the air shall reach 5 or 7 feet a second in order to secure the permanence of the current.

At the foot of this chimney, a grate, separated from the walls and placed about 3 feet above the ground, should contain a coal-fire, which will give to the draught the necessary strength. Experiments show that with proportions about equal to those that have been mentioned, 140,000 to 160,000 cubic feet of air an hour can be carried off from a well-filled lecture-room to every pound of coal burned. On the preceding data, the number of pounds of coal to be burned may be calculated from the number of persons in attendance allowing to each 1,000 cubic feet of air an hour, and the surface of the grate may be determined on the condition that each square foot is to consume 4 pounds an hour, which corresponds to a slow fire.

Doors and valves should be placed in this gallery to check the motion of the air as required.

If in the lecture-room substances that give off bad smells are produced, ventilating-pipes should be arranged under the furnaces, or under the table, which should be 2½ or 3 square feet in sectional area, and prolonged, if desired, directly to the chimney instead of terminating in the gallery. The openings of these pipes in the furnace or in the table should be closed whenever it is not necessary to use them.

121. *Admission of fresh air.*—Generally it will be well, when the construction permits, to make the air flow in through the roof over the lecture-room, which should in that case be closed and sealed, or in an interjoist, whence it will descend into the room through openings uniformly spread over the surface of the ceiling.

When this arrangement can be adopted, the clear surface of the openings should be calculated on the condition that the air should pass through them with a velocity of about 20 inches a second.

In the main lecture-room of the Conservatory, where the amount of air admitted rarely exceeds 636,000 cubic feet an hour, or 177 cubic feet a second, this condition would require a clear area for the fresh-air openings of 108 square feet. They actually have an area of 129 square feet.

If it becomes necessary to admit the fresh air through one or more of the walls of the room, opposite walls should be preferred, and the openings should be placed as far as possible from the audience, fitting guides to them to force the air to follow the flat or curved surface of the ceiling, so that its entering velocity, which may then be as great as 40 inches a second, may be gradually reduced before it reaches the audience. The air brought in should have in winter a temperature lower by 4 degrees than that which is to be maintained in the room, which should be about 68°.

For this purpose, the warm air from the heating apparatus should be mixed in a separate chamber with the cold air taken from outside through a convenient opening. The action of the draught will serve to draw in this cold air, which should be made to flow into the mixing-chamber above the warm air.

Valves should be arranged to regulate the amounts of hot and cold air so as to give a proper temperature to the mixture.

When the lecture-room is not occupied it would be well to close all communications with the ventilating chimney, the mixing chamber, and the fresh air openings, in order to avoid reversed draughts which would cool the interior.

The intermittent use and heating of lecture rooms causes a much greater expense for fuel than if they were constantly occupied.

These places also being only ventilated when they are in use, it is well to reserve means of warming through special openings different from those which are used in connection with ventilation, the openings to be afterward closed.

The mean results for heating and ventilating lecture rooms arranged similarly to those in the Conservatory will be as follows:

Consumption of coal in 12 hours.
- For heating—to 1,000 cubic feet content ... .2–2¼ lb.
- For ventilation—to 1,000 cubic feet of air renewed, ¼–1 lb.

Large reception rooms, such as those of legislative halls, should be warmed and ventilated upon the same principles.

In all cases, it should be remembered that staircases, vestibules, etc., which give access to these places with strong ventilating draughts, should be warmed without being ventilated, and kept at a temperature a little above that of the main room, so that the occasional opening of doors will only admit warm air, which would not be unpleasant.

Experiment has shown at the Conservatory that, when these places are thus heated and kept closed, they form a sort of air-lock, and the velocity with which the air enters through the doors, which being opened put them in communication with the interior of the lecture room, is barely one foot a second, and consequently almost insensible especially if the temperature of the air is at least equal to that in the main room.

THEATERS.

122. A theater is composed of three principal parts—

1. The stage and its accessories.
2. The auditorium, waiting-rooms, and dependencies.
3. The vestibules, staircases, and business offices.

The stage, the flies, and the corridors which lead to the dressing-rooms and green-room, should be kept at a temperature of 64° to 68° in winter. Generally, the latter places will not require to be ventilated, as they contain but a small number of people occupying a large space. Still, as the green-room, and the rooms in which the chorus rehearses, often contain a large number of artists, it may be necessary in certain cases to ventilate them. The upper portions of the stage are often raised to a high temperature on account of the heat produced by the lights, by the fire in spectacles, etc., which requires that special precautions be taken to air them and to remove the hot gases.

The auditorium and the waiting rooms are the parts in which it is especially desirable to retain salubrity, change of air and a moderate temperature. The amount of air to be changed an hour to each spectator should be 1,400 cubic feet, and it is well to reserve means of increasing it to 2,100 cubic feet during the summer.

The heating may be effected either by means of hot-air heaters with sufficiently large mixing-chambers, as has been previously mentioned, or by hot water apparatus, of which the first cost need not be greater than the preceding, while it will be very easy to regulate.

123. *Air-supply.*—The fresh air should be taken, if possible, from the neighboring gardens, far from dwelling houses, or from court-yards, or by special chimneys, drawing it from the top of the edifice. Care should be taken that these chimneys should be as far as possible from the ventilating chimneys, and that their tops be not as high as the ventilating chimneys, in order that they may not reverse the draught.

If fresh air be introduced by subterranean passages, the walls, the vaults, and the floor of these passages should be made of hydraulic masonry, perfectly tight, and nothing should be done to them by the custodians of the building, except to examine their state of cleanliness.

124. *Admission of air.*—The air should be carried into the auditorium:

1. By interjoists, formed between the floor of one gallery and the ceiling of that below; the air should issue horizontally from the whole circumference of the interjoists, which should be at least 5 or 6 inches in clear height.

It may be assumed that the horizontal velocity with which it flows out will be 3 feet a second; but it is necessary to take care that the openings through the gratings which terminate the interjoist spaces have at least a surface corresponding to this velocity, and that none of these openings be placed horizontally above the spectators of the lower tier of seats.

2. By openings arranged at the height of about 10 feet in the walls separating the stage from the auditorium, and there may also be formed there a chamber for mixing the warm air from the heaters with the cold air from outdoors.

3. By auxiliary pipes, intended especially for summer ventilation, arranged, if possible, under the floors of the corridors of each gallery. They should take air from outdoors, and their section should be calculated, so that the velocity of passage shall not exceed 2 feet or 28 inches a second. All these pipes should be supplied with valves to close them when required in cold weather.

125. *Necessary precautions* —Ventilation, by drawing out the foul air, necessarily causing the entrance of fresh air, it is necessary to see that the opening of doors does not occasion unpleasant currents. For this purpose, corridors, passage ways, and stair cases should be heated in winter to a temperature of about 68°. The doors of adjoining boxes being usually contiguous, it will be well to place a hot air opening in the corridors before each pair of doors, so that during the momentary opening of one of these doors warm air may enter into the corresponding box. The same plan may be carried out by each door in the passageway; but it is necessary that these hot air openings be placed in vertical planes, and not at the floor level. The passageways should have two doors opening outward and inward, and between them should be a hot air opening.

126. *Removal of foul air.*—This air should be drawn out of the room by ventilating openings at the back of the boxes or galleries, or in the risers of the amphitheater. The clear surface of these openings should be calculated on the condition that the air shall enter with a velocity of 28 or 30 inches a second.

Each box, or each pair of adjoining boxes of the same tier, should have a special ventilating pipe. The section of these pipes should be calculated on the condition that the air drawn out should have a velocity of three feet a second. For the first, second, and third galleries, these pipes should be carried to the ventilator above the chandelier.

For the parquet, the orchestra, and the lower boxes, and, if possible, for the first gallery, the foul air pipes should descend. In the parquet and the orchestra, gratings arranged around the whole lower circumference of the partitions, together with other openings placed on top or on the sides of pipes carried along by the feet of the seats, will serve to direct the foul air in an interjoist placed under the floor. This interjoist, made high enough to be cleaned, should be divided in large theaters into two parts by a longitudinal division in the mean plane of the edifice.

Each of these parts should communicate with a separate ventilating chimney, of which the opening should either be in the basement or at the height of the floor of the passage ways in the parquet.

In no case should the ventilating openings be placed at the floor level, as has nevertheless been done at the Lyric theater.

The foul air drawn off from the lower boxes and the first gallery should likewise be carried underneath by means of special pipes, afterward united in collecting pipes terminating at the base of the chimneys just referred to.

The dimensions of these pipes should be determined on the condition that the velocity in them should be from 3 to 4 feet a second.

In small theaters, a single chimney will usually suffice for all the galleries. The calculation of the dimensions to be given to the foul air openings should be made for each gallery separately, from the corresponding number of spectators.

The cast-iron smoke pipes of the heaters should be carried into the ventilating chimneys, keeping them separate throughout their whole height; and at the lower part of the chimney a grate should be placed, to be used whenever required, to increase the draught, especially in summer. It would not be prudent, even in winter, to count upon the heat transmitted by the smoke pipe to produce a sufficiently powerful draught.

The sectional area of the chimney should be calculated so that the mean velocity in it may be 5½ or 6 feet a second.

They should open, when possible, in a cupola, placed above the center of the hall, which should also receive all the ventilating pipes of the upper stories.

A main ventilating chimney should be constructed of brick, and not of metal, above this cupola, the latter to be as low as possible, while the chimney should be made as high as the nature of the building will permit, but at least 20 or 25 feet.

The sectional area of this chimney should be calculated on the condition that the mean velocity of the draught in it should be about 6½ feet a second.

127. *Utilization of the heat given out by the lights.*—In addition to the pipes for carrying off foul air, the gases produced by the burners of the main chandelier, or the other chandeliers suspended from the ceiling should also be carried into the cupola. The pipes intended to carry the gases there should be made as small as possible in order not to change the direction of the main draught in the vicinity of these places.

The diameter of the ventilating pipe above a chandelier placed near the ceiling and supplied with a metal or glass reflector should be calculated under the condition that it shall only remove 150 cubic feet of air an hour, with the velocity of 13 feet a second to a cubic foot of gas consumed by the chandelier.

The single burners in the boxes and corridors should take the air necessary to support the combustion in the interior of the boxes or from the adjoining ventilating pipes. It will suffice to make their ventilating pipes ½ or ¾ inch in diameter.

If, as is most probable, the plan of lighting through a glass ceiling, tried at the Théâter du Cirque and the Lyric Theater, be not adopted, it will be advisable to place a circle of gas jets at the base of the ventilating chimney, to be used only to increase the draught in summer, when the elevation of the temperature of the external air tends to reduce it. It may be assumed that under similar conditions each cubic foot of gas consumed will carry off about 800 cubic feet of air.

A valve should be placed at the foot of the chimney to moderate its draught, and particularly to stop the draught after the close of the play, to prevent useless loss of heat and the entrance of cold air during the night.

128. *Ventilation of the stage.*—For theaters where great quantities of smoke are frequently produced during sham fights, grand illuminations, displays of fireworks, etc., it is well to keep up a strong draught in the upper part of the stage, in order to prevent the gases from being drawn into the auditorium by the draught kept up there, as happened at the Chatelet Theater, where these precautions were not taken. Furthermore, in order that this stage ventilation may not interfere with that of the body of the house, it is necessary to connect the two systems with each other.

For this purpose, a chimney or an auxiliary ventilating flue should be made above the stage and joined with the main chimney, the draught of which should be increased by means of gas jets lighted at the proper time, a little while before the smoke is produced.

129. *Precautions to be taken to prevent re-entry of the external air on the stage.*—The introduction of external cold air on the stage should also be avoided, in order that currents from the stage to the hall may not be produced, which would be disagreeable both to the actors and to the audience. This result has taken place at the Théâter du Cirque, where large openings in direct communication with a court and public way have not been closed.

130. *Lighting apparatus for the auditorium.*—Without wishing to specify here the arrangements to be adopted for lighting theaters, we will confine ourselves to stating that glass ceilings, which require to be ornamented with colored designs, occasion a considerable loss of light, while they produce in the room an amount of heat very unpleasant for the spectators in the upper tiers, and which is also very expensive for the directors, who are naturally led unduly to restrict the number of gas jets, thus rendering useless the expense gone to in introducing this method of illumination. Although this consumption, even when thus restricted, assists the removal of foul air, the amount carried off is seldom more than 4.0 cubic feet to a cubic foot of gas burned, while with suitable arrangements the amount of 600 to 800 cubic feet of air might be carried off to every cubic foot of gas.

131. *Arrangements to be made to secure and regulate the amount of warmth and ventilation.*—Warmth and ventilation can only be properly secured by an attentive observation of atmospheric conditions and of the number of spectators, and by prompt application of the proper means. There is, in fact, no difficulty in the arrangement or the management of the apparatus; but it is necessary to take care, and not to trust to ordinary firemen, nor even to the managers of theaters, always interested in using as little coal and gas as possible.

It is then indispensable to confide this trust to special agents, responsible directly for the authority and the regularity of the service, and obliged to make daily reports. Without such control, independent of theatrical managers, the best apparatus may give imperfect results or even fail entirely.

132. *Application.*—The preceding rules have been adopted

* Translated for the Smithsonian Institution by Clarence B. Young.

after long discussion and many experiments,* to serve as bases for the plans to be adopted at the Lyric Theater and the Chatelet Theater. The city government has scarcely any control over the latter, and but little over the former. Still, as the results obtained at the Lyric Theatre have, in the main, been somewhat satisfactory, when the apparatus has been properly managed, I will describe this first application, in spite of its imperfections.

The auditorium, intended to accommodate 1,700 spectators, has really but 1,472 seats, distributed as follows:

Orchestra, parquet, and lower boxes		440
First tier	256	
Second tier	302	
Third tier	178	
Fourth tier	296	
	1,032	
	1,472	

The amount of air to be renewed for each spectator had been limited to 1,060 feet an hour, which, with the above number of places, corresponded to a total volume of 1,560,000 cubic feet an hour. The conditions imposed upon the contractor, based on the hypothesis of 1,700 spectators, would require a renewal of 1,800,000 cubic feet of air an hour.

133. *External air supply.*—The air supply was taken in St. Jacques Square from a circular well 12 feet in diameter, which, by a subterranean passage, at first circular, 11 feet in diameter, and afterward of variable form, but of the same sectional area, carried to the subbasement of the building, and spread it over the whole extent occupied by the heaters and the air-chambers. The sectional area of the passage way was therefore but 98 square feet; and experiment (December 9, 1862†) having shown that the velocity in it was as much as 6 feet a second, the volume of fresh air introduced by this gallery was that day 1,090,000 cubic feet. It was only deemed necessary to introduce 1,060,000 cubic feet, since the unavoidable admission of air through the doors, the passages, and the stage would easily and without inconvenience furnish the balance, as has been found to be the case. It would, nevertheless, be more prudent in such cases to calculate the dimensions of the fresh air trunk to furnish the entire amount.

134. *Alteration of the adopted plans.*—But a little while after the opening or the lease of the theater to the manager, the external fresh air passage was closed, and even the pit in St. Jacques Square covered with ivy. Thus the introduction of air by these passages, as well as by the pipes leading to the interjoists of the boxes, is almost entirely prevented, while the outward draught is as strong as ever. It therefore follows that, to replace the air carried off, cold air enters through the halls, passages, etc., which is very unpleasant for the spectators, and which the public attribute to the general arrangements adopted, while they are only the result of want of care and of the exercise of authority.

In spite of the influence which these changes, and others equally serious, in part of the apparatus have had on their operation, I will describe the results which have been obtained by continuous service when the ventilation has been regularly kept up.

135. *Ground floor.*—Part of the air supplied by the air-trunks passes into two heaters placed under the main hall; the rest flows into two mixing-chambers, having together a capacity of 6,500 cubic feet. The two heaters have a sectional area of 97 square feet, and the amount of warm air which they can supply to the mixing-chamber, being at a maximum 883,000 cubic feet an hour, or 245 feet a second, this corresponds to a velocity of 2½ feet a second.

From the air chamber, and from each of its compartments, branch off six pipes, of which—

Two are intended to supply fresh air to the different galleries.

Two were to supply air entering the room by the floor of the stage, concentric with the footlights. This method of introduction had to be abandoned, as it was unpleasant to the musicians.

Two were to carry air in vertical pipes placed by the stage-opening against the wall which separates it from the auditorium.

There are, in addition, four heaters for warming the vestibules, the staircases, waiting-rooms, dressing-rooms, etc.

136. *Removal of foul air.*—In the orchestra and parquet, the air is drawn off under the floor by 101 openings, having altogether a clear area of about 65 square feet. The passage under the floor, which should have had a clear area of 118 square feet, has been reduced to 40 square feet.

The air drawn off at this height, carried by two pipes to the right and left, is drawn to two ventilating-chimneys, which contain the smoke pipes of the heaters of the hall, and may also, when necessary, be heated by a small special fire.

Direct experiments, made during five consecutive evenings in May, 1863, with external temperatures comprised between 56° and 73°, have shown that a mean consumption of 441 pounds of coal, costing about $3 for each performance, effects the removal of about 600,000 cubic feet of air an hour, which corresponds to about 1,400 cubic feet to a seat. By means of this abundant ventilation, the temperature of the orchestra and parquet may be maintained within proper limits.

But the managers of the theater do not use the two ventilating-chimneys; and if they have not been closed, instead of promoting the removal of foul air, they may cause the entrance of cold air, in consequence of a reversal of the direction of the motion of the air caused by the greater power of the upper draught.

For the first, second, third, and fourth galleries, the foul air is carried out at the floor of the galleries or through the steps of the amphitheater, as was remarked in § 126; and the observations made in May, 1863, have shown that the amount of foul air extracted at the base of the cupola was as much as 1,361,000 cubic feet for 736 places, equal to 1,848 cubic feet to a place. For the whole audience room, containing 1,472 places, the total amount of air removed on an average during the five evenings in May, 1863, when the observations were made, was as much as 1,970,000 cubic feet, or 1,338 cubic feet instead of 1,060, which was all demanded. The total amount was even raised on December 3, 1862, to 2,121,000 cubic feet an hour.

137. *Maintenance of equality of temperature in the different galleries.*—I have given in my investigations in regard to ventilation* the results of experiments which have been made under very different temperatures, and which have shown that the results obtained have exceeded what was required as to the amount of air removed from the room at the different galleries. The results relative to keeping up the temperature have not been less satisfactory. In fact, by means of this regular ventilation, the temperature at the different galleries has been maintained at a very remarkable state of uniformity, as shown by the following results for the first and fourth galleries, which alone will be cited here:

DATE.	Mean external temperature.	First gallery, mean temperature.	Fourth gallery, mean temperature.
	° F.	° F.	° F.
May 24, 1863	52·25	69·10	69·80
May 25, 1863	55·85	71·60	74·66
May 26, 1863	55·85	71·60	72·05
May 27, 1863	59·90	75·02	75·02
May 28, 1863	62·60	75·92	76·64
May 29, 1863	67·10	76·10	77·36
May 30, 1863	69·80	78·26	80·06

It is well to repeat that in a place strongly ventilated a temperature of 75° does not feel unpleasant, and that if the direct external air openings required for the summer season have been made it will be easy, if required, to obtain a still smaller difference between the external and internal temperatures.

At the old Opera, the Italian Theater, and most of the unventilated theaters, it is not unusual to observe temperatures of 95° and 105°.

138. *Temperature on the stage.*—When the heaters designed to warm the stage are well managed, a proper degree of temperature may always be maintained there. Thus, in November, 1863, with an external temperature of 39°, was obtained—

	° F.
On the stage	66·02
In the orchestra stalls	70·88
In the gallery-boxes (average)	72·32
In the amphitheater (fourth gallery)	73·94

In May, with external temperatures of from 64° to 68° at 7 o'clock, and from 55° to 57° at midnight, the temperature on the stage was on an average 71° to 73°.

139. *Volume of air carried off at the cupola to a cubic foot of gas burned.*—During the experiments of May, 1863, the volume of gas burned an hour in the main room was on an average 2,940 cubic feet, and the volume of air was 1,361,000 cubic feet, which corresponds to 462·5 cubic feet of air carried off by a cubic foot of gas consumed. But in the above-mentioned consumption is included that of a large number of burners which had no direct influence on the ventilation. A removal of 600 to 800 cubic feet of air to a cubic foot of gas directly consumed to produce it may be calculated upon when proper arrangements are made.

140. *Consequences of the preceding facts.*—The results of direct experiment made in different seasons show that the arrangements adopted for warming and ventilating the Lyric Theater are capable of producing satisfactory results. The same is true of the Gaîté.

It is a pity to see the public, in consequence of the senseless parsimony of the manager of a theater, deprived of the advantages which the administration of the city of Paris has, at considerable expense, undertaken to secure them.

STABLES AND COW-HOUSES.

141. The capacity of stables should be 1,800 cubic feet to each animal; this was the proportion adopted in 1841, by the war-minister for cavalry stables. In all constructed since that time for the army service, the width allowed for each horse is about 4½ feet.

WROUGHT IRON GATE. DESIGN OF EISENLOHR AND WEIGLE, FROM THE WURTEMBERG EXHIBITION, 1881, STUTTGART.—*The Workshop.*

This increase of space produced from 1835 to 1858 a reduction in the number of horses lost in 1,000, from 51 deaths by glanders in the period from 1835 to 1845 to 10 only during that from 1845 to 1858, and from 94 deaths from all diseases in 1835 to 1845 to 22 only from 1848 to 1858.

Large corporations, such as the General Omnibus Company and the railroad companies, are then wrong in restricting the capacity of their stables to 700 or 900 cubic feet of air to a head.

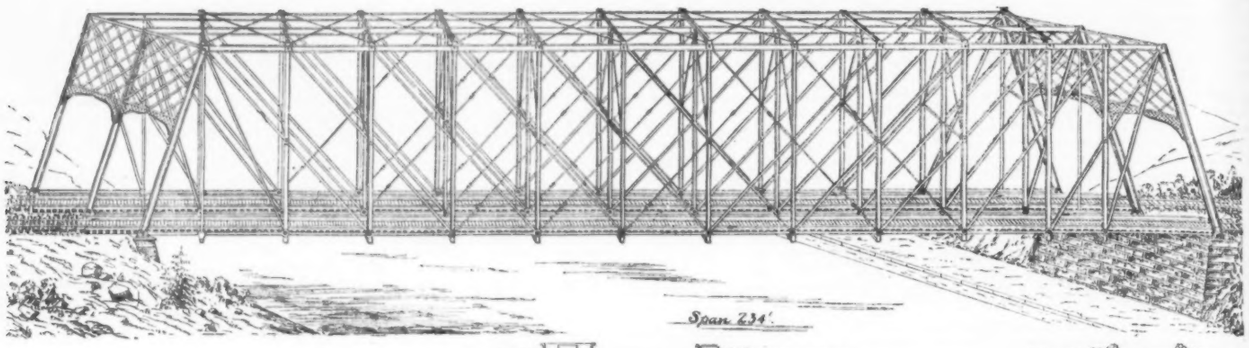
142. *Permanent opening of doors and windows.*—Experiments carried on for several years in cavalry regiments in garrison in the north, center, or south of France have proved that horses have better health and greater strength when kept in stables where the doors and windows are constantly kept open night and day in all seasons than where they are kept shut. Similar observations have been made in stables containing a great many cattle, which are thus relieved from epidemic affections of the respiratory organs.

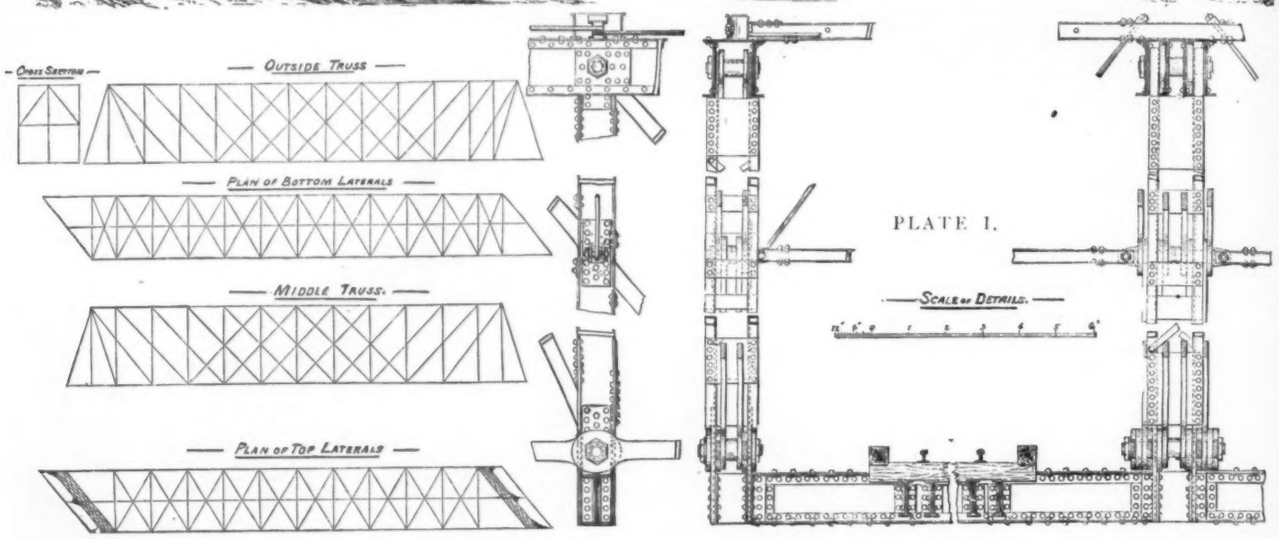
143. *Amount of air to be allowed.*—When stables are not arranged so as to admit air throughout their whole length and by two opposite walls, it is proper to make in the roof at the middle of the alleys, if they are double or above the

* The commission charged with the investigation of the question and the examination of projects was composed of Dumas, member of the Institute, president; Chaix-d'Est-Ange, Poisonse Rayer, Gilbert, Caristie, Baltard, General Morin, members of the Institute; Grassi, chemist.

† "Etudes sur la Ventilation," vol. II.

* "Etudes sur la Ventilation," vol. II.

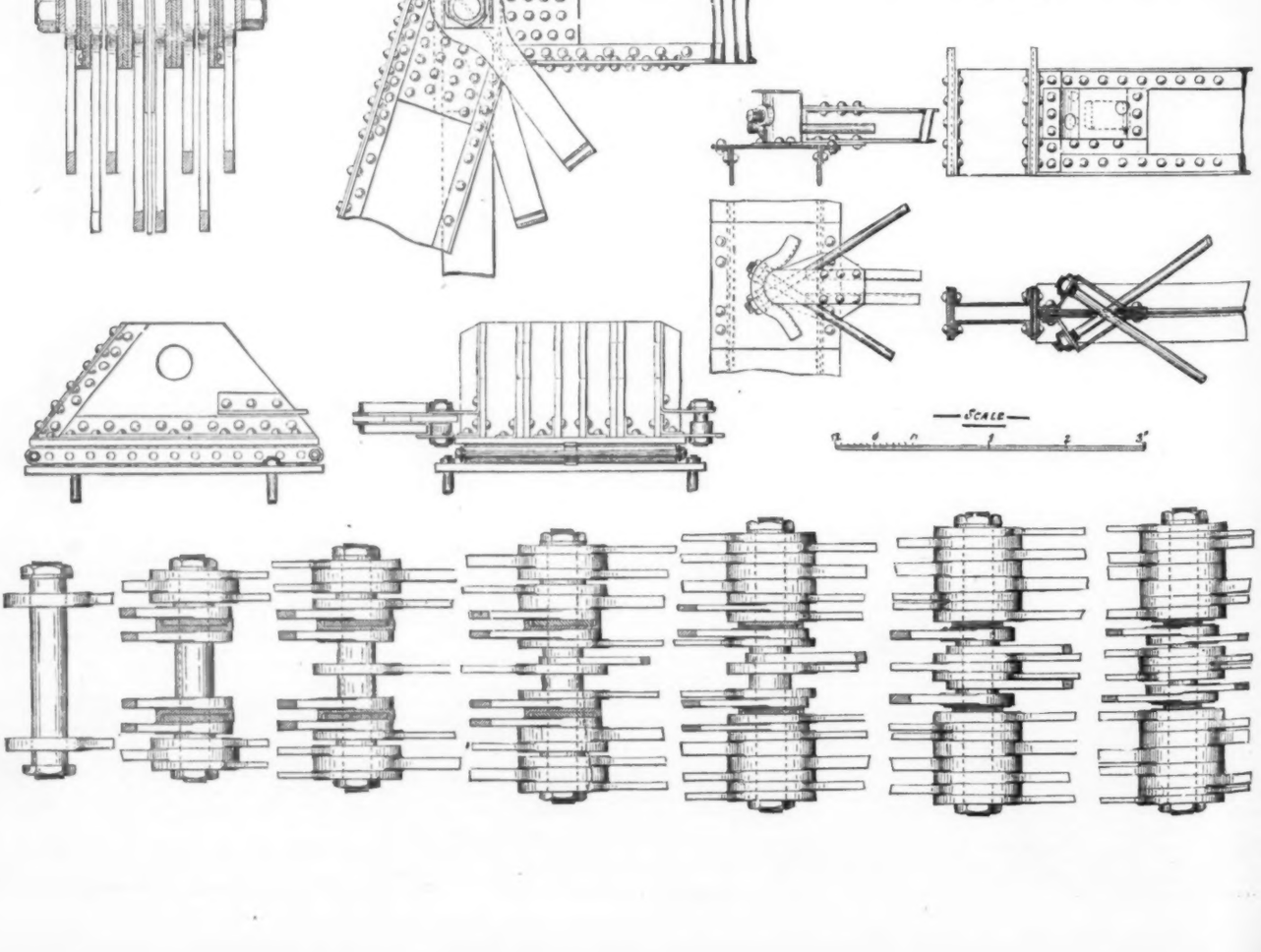




ERIE CANAL BRIDGE.

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD.

Built in 1880 by the Keystone Bridge Company, Pittsburgh, Pa.



passage behind the horses, ventilating chimneys of brick sufficiently large to secure a ventilation of 6,400 to 7,000 cubic feet of air an hour to a horse, with a velocity of 28 inches a second, which may be produced by a difference of temperature of 11° to 13° between the external air and that of the stable. This requires that the chimneys have a sectional area of 108 to 124 square inches to a horse.

By means of this ventilation, the hygrometrical condition of the air in the stable will be maintained within convenient limits.

144. *Use of gas burners.*—The ventilation of stables may be increased by making use of the heat given out by gas burners used to light them up at night, which then allows of reducing the sectional area of the ventilating pipes.

145. *Cow houses.*—What precedes relates to work animals. In the case of the milch-cows it appears that a certain drowsy laziness is favorable to the production of milk; and in such cases it is necessary to limit the ventilation to what is absolutely necessary for health.

MEANS OF CONTROL.

146. *Means to be used to determine the condition and the results of a system of ventilation.*—It has been shown by the numerous examples that precede that the establishment of a complete and regular renewal of air in occupied places in reality presents no difficulty, and that the rules to be followed are very simple. Their application will be equally so, and will involve but little expense if architects take care to devise plans of ventilation at the same time that they make the plans for construction, instead of waiting till the building is almost finished.

But when all the arrangements have been made to secure the renewal of air, the first thing to do is to examine whether the desired results have been obtained, and the second is to regulate the operation of the apparatus.

To determine what are the amounts of air carried off and drawn in, a small portable instrument is used, called an anemometer, consisting of a wind-mill with light and easily moved vanes, connected with gear-wheels and pointers, which indicate the number of turns made by the vanes in a given time.

Experiments show that with an apparatus of this kind the velocity of the air may be deduced from the number of turns of the wings by means of an equation of the form:

$$V = a + b\,N,$$

V being the velocity in a second;
a, a constant term, expressing the velocity of the air at which the instrument commences to move;
b, a constant number;
N, the number of turns indicated in a second.

Thus, one of the anemometers of the Conservatory has the formula:

$$V \text{ (in inches)} = 8{\cdot}66 + 7\,N.$$

This instrument should be placed, as far as possible, in a part of the flue traversed by the air, where the velocity is uniform and well regulated. It should be kept in operation at least two minutes, if a watch indicating seconds be used; and four or five, if a watch indicating minutes only is employed. From the number of turns made in this interval of time may be deduced that corresponding to a second, whence the velocity, V, may be obtained. This velocity, multiplied by the sectional area of the flue, will give the amount of air passing through in a second, and from this the amount passing through in 3,600 seconds, or an hour, can be obtained.

If it be feared that the velocity in the flue is variable, on account of its large size or other circumstances, it will be necessary to try the instrument at different places, which will then give with sufficient exactness the mean velocity of the air.

When it is desired to determine the volume of air which is carried out or drawn in through an opening covered with a grating, the anemometer should not be placed above or in front of this opening, as is done by many observers, and the velocity resulting from the number of turns observed taken as the mean velocity of the air passing through. Serious errors will result from this method. The proper way is to place before the opening, and fitting to it as closely as possible, a pipe having at one end the form of the opening, and joining at the other end a cylindrical pipe at least two feet long, in which the anemometer should be placed, which would then indicate the velocity of passage in this part of the auxiliary pipe. The velocity of the air introduced or withdrawn in a second or an hour may easily be deduced afterward.

147. *Means of insuring the regularity of the ventilation.*—While the use of portable anemometers serves for experimental investigations and for the determination of the results obtained by the ventilation, it is not sufficient to secure the necessary regularity of ventilation in large establishments.

In such cases it is necessary to introduce much larger anemometers, connected with an electrical recording apparatus placed in the office of the superintendent, or in a conspicuous place where it can be seen every hour, or every morning and evening, whether the renewal of air is proceeding with regularity and with the prescribed energy.

This is not the place to describe the apparatus.* I confine myself to stating that an anemometer of the kind has been employed with success for several years at the Conservatory of Arts and Trades, to insure regularity in the ventilation of the lecture rooms; and that every year it works for about five consecutive months without derangement, and without requiring any care but the renewal of the solutions in the battery two or three times a season.

A similar anemometer has been in constant operation for several months in the ventilating chimney at Lariboisière Hospital, and has served to show, every morning, the amount of foul air removed from a wing containing 106 beds, during the night, and, every evening, the amount during the day.

Methods of observation of this kind, automatic and independent of the personal action of the employés, are the indispensable adjuncts of great ventilating systems, if it be desired that the service be performed in a regular manner. They also serve to render the work of inspection by the heads of the establishment more easy and efficient.

RAPID GROWTH OF NEW YORK.—The annual report of the City Inspector of Buildings shows that during the past year plans for 2,682 buildings, to cost $43,391,300, were filed at the Building Bureau. In 1880 the number of new buildings erected was 2,252, at a cost of $29,115,335. There were more buildings erected last year, and their estimated cost was greater than in any previous year.

* See the "Annales du Conservatoire," vol. v., 1864, p. 341.

ERIE CANAL BRIDGE.—NEW YORK CENTRAL AND HUDSON RIVER RAILROAD.

THE angle of the center line of the bridge with the abutment is 52°. It is a double track through bridge, the middle truss being made of twice the carrying capacity of the side trusses. The floor is very shallow, made so by the necessity of obtaining as much clearance as possible for boats passing on the canal below. The span length between centers of end pins is 234 feet. There are ten intermediate panels of 18 feet 5 inches, and two of 12 feet 1 inch and two end panels of 12 feet 10 inches each; width between center of trusses 15 feet 6 inches. The depth of trusses is 40 feet between centers of chords. The rolling loads for which the trusses were proportioned were 3,000 pounds per lineal foot of each track; 10,000 pounds per square inch was allowed in tension, and 8,000 pounds in the numerator of Gordon's formula in compression. The long intermediate posts of the trusses are fixed in position about midway with a pin, connecting them with the main ties and transversely by a substrut and vibration rods. The total finished weight of the structure is 647,000 pounds. (See cut opposite.)

The bridge was erected in the spring of the year 1880—while boats to the number of 100 per day were passing under it—by the Keystone Bridge Company, of Pittsburg, Pa.—*Amer. Engineer.*

THE FIRELESS LOCOMOTIVE ON TRAMWAYS.

THE economical advantages of traction on rails, and the immense services rendered to traveling and to transportation of freight by steam railways, could not, as a matter of course, have failed to inspire the idea of applying the same system of tracks and traction on ordinary roads. As far as the road is concerned, the problem has been solved; and, in fact, the laying of rails on roads was begun on a small scale, even before the construction of railways, properly so called, designed for traction by steam. But the question of motive power is a more difficult one, and we cannot say that, at present, notwithstanding the multiplication of tramways, it has been fully solved. Traction by horses cannot be accepted as a definite solution; for, although the labor of traction is considerably diminished, even by the use of the very imperfect system of rails ordinarily adopted, it must unfortunately be confessed that the tractive power of animals is not a manageable one like that of steam, and that accidents on the road, difference of grades, multitudinous stoppages, and the action of the collar, promptly lead to a wear and tear on the living machine; and it would not be difficult to prove by figures that traction on tramways is no more economical than that of omnibuses drawn by horses. It is very natural, then, that the idea should have occurred to have tramway cars drawn by a locomotive. But here, outside of some technical difficulties, there has presented itself a legal one.

A regulation of public administration, rendered on the 8th of August, 1881, in execution of the law of the 11th of June, 1880, contains the following:

Art. 31. Steam locomotives must give out no odor, and must not scatter along the public highway sparks, cinders, or water, nor give out smoke, the grantee being expressly responsible for every fire caused by the use of engines using fire, either on the public road or in property bordering thereon.

Art. 32. Every steam engine is to be driven by one engineman and one stoker.

To authorize the use on the public road of steam engines, on condition that they emit no smoke, odor, etc., looks very much like a prohibition; and one might, on reading such an enumeration, expect to see steam engines forbidden to produce any heat.

Article 31 is, in fact, an absolute interdiction to the use of steam locomotives on roads and tramways; but we can scarcely blame this measure when we come to reflect upon the disadvantages and dangers of such motors under like conditions. The question remained to know whether the use of steam could be conceived of independently of that of any sort of fireplace whatever.

This curious question, which at first sight has some resemblance to a paradox, was taken up almost at about the same time by a French engineer, Mr. L. Francq, and by an American engineer, Mr. Lamm, who succeeded, in fact, in running a fireless steam locomotive through the streets of New Orleans.

During the course of his studies and experiments, and after the premature death of Mr. Lamm, Mr. Francq came into possession of the latter's patent, and soon ascertained the radical defect of the American locomotive—a defect, moreover, which, being inherent to the system adopted, was apparently incapable of being overcome.

The general idea of the American engineer, like that of the French one, was this: to develop steam at a high tension in a stationary generator; to introduce it into a closed receptacle partially filled with water, so as to liquefy it almost totally, under the double influence of the internal temperature of the water and the pressure; to take it up again in the state of steam and make it operate the steam already obtained under the piston of the locomotive, thus materially lowering at the same time the tension in the receptacle, and the temperature of vaporization of the water contained therein.

That is the principle. The drawback that Mr. Lamm had in nowise obviated was this: in measure as the steam is used that is produced in the receptacle at lower and lower temperatures, the temperature of such steam diminishes, the tractive power grows weaker in the same proportion, and the motor soon loses in speed and becomes powerless to cross accidental obstacles, to ascend grades, and to start again after stopping. It becomes radically powerless, in fact, if the route to be gone over extends to any little distance.

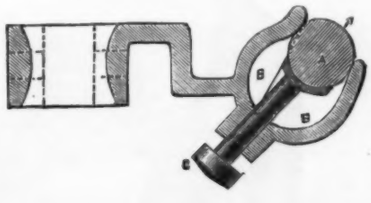
As may be seen, the problem is a difficult one; yet Mr. Francq succeeded in solving it, after lengthy experimentation, by the aid of an ingenious distributer which regulates the expenditure of steam in a proportion inverse to its tension. Mr. Francq's fireless locomotive has now been in successful operation for four years on the line from Rueil to Marly, and on that from Lille to Roubaix, and its principle has been applied by the French Government for the navigation of the Canal of the East.

The machine, emitting no odor or smoke, dropping neither sparks, ashes, nor cinders; being in no danger of exploding; being exceedingly easy of management, and dispensing with a stoker, etc., we shall not say that it meets the requirements of the act of 1881, for that would not be saying enough, since it gets around the act entirely, inasmuch as it is not a *fire-carrying* apparatus, and possesses none of the disadvantages of such. Our engraving shows a train of tramway cars drawn by one of Mr. Francq's locomotives.

TRAMWAY CARS DRAWN BY FRANCQ'S FIRELESS LOCOMOTIVE.

CLIP FOR TENTERING MACHINES.

THE usual way of holding the selvage of the cloth in a tentering or stretching machine is by means of either pins or clips. The former are objectionable in many cases, on account of their liability to make holes in the cloth, and the clips have the fault of all contrivances held by springs, viz., that in course of time the springs lose their elasticity, and then refuse to perform their office. The contrivance which we here illustrate has been invented to overcome the objections of both pins and clips, and consists of a clip or bracket in the shape of a horseshoe, B, into the opening of which a ball, A, fits partly, but so that it cannot pass through



it. If now the selvage of the cloth is passed through this opening, and the ball pushed forward by the pin, C, it will hold the cloth the tighter the more the latter pulls. By withdrawing the pin the cloth is then easily disengaged.

ACTION OF LIGHT UPON OXYGEN.—J. Dessans has contrived an apparatus for governing the admission of the radiations from a Drummond light into a jar of oxygen, and he concludes, from experiments which he has frequently repeated, that light effects a direct transformation of oxygen into ozone. In the course of his experiments he sometimes used the oxygen as pure as possible, and in other cases he introduced substances which are easily oxidizable, so that they might readily combine with the ozone. Both methods of experimenting led to the same result.—*La Nature.*

MACHINE FOR THE MANUFACTURE OF WOODEN SHOES.

FOR some time past the application of machinery to the manufacture of wooden shoes has been rendered practical by special tools that have been improved by Mr. Arbey. Some means of rapid manufacture has become necessary owing to the difficulty that manufacturers are experiencing in procuring skilled hand workmen, and also to the fact of a greater and greater demand for the goods.

The new system comprises five different machines. First, there is an endless band-saw the diameter of whose pulley is one meter. This machine, which is entirely of cast iron, is provided with an inclinable table so as to permit of sawing in relief or cross cutting, and receives the rough blocks of hickory, beech, or birch to be cut into slabs having a thickness equal to that of the shoes to be made. These slabs are afterward placed flat on the saw table and divided into quarters.

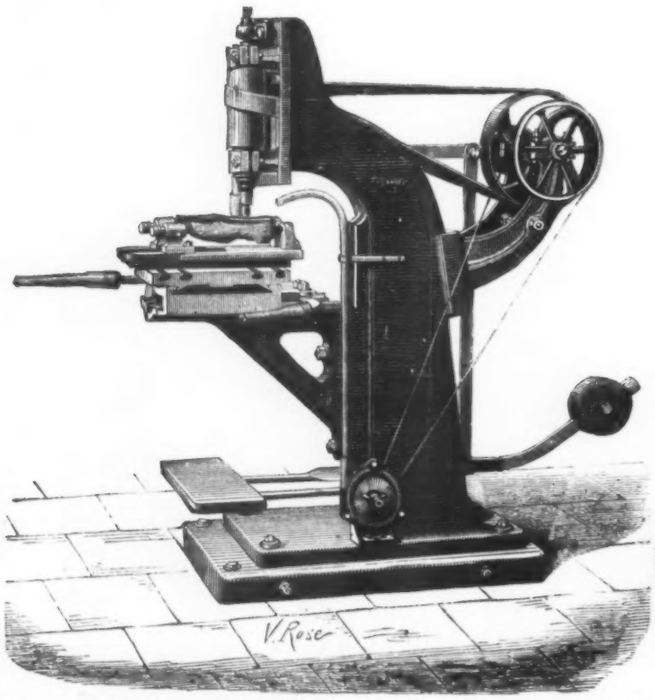


FIG. 1.—MACHINE FOR HOLLOWING OUT THE HEELS OF THE SHOES AT ONCE.

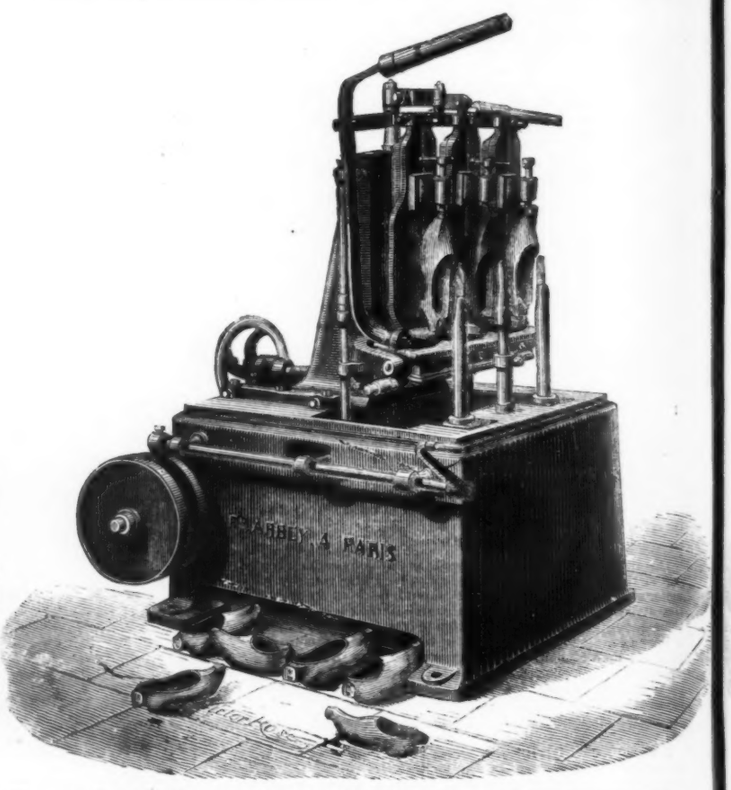


FIG. 2.—MACHINE FOR HOLLOWING OUT THE FRONT OF THE SHOE.

The pieces of wood are next operated on by means of a band saw smaller than the former so as to give them the rough outlines of the shoes. These two operations being effected, by means of saws such as are ordinarily in use, the shoes in the rough are placed in a shaping machine of special construction, which is made in three sizes, according as it is desired to operate on two, four, or six shoes at once. In this machine two shapers, having the exact form of the shoe to be made, are fixed to a carriage, and, like the roughly formed shoe, are carried between slidi g poppets and supports. Each of these latter is traversed by an axle which gives a rotary motion to the shoe or to the corresponding model. Against each cast-iron shaper there rests an extensible follower, having an outline similar to that of the six blades which are arranged on a horizontal axle running between two supports. During the operation of the machine the blades carve out the more or less pronounced rounded portions of the model to be imitated, the contours of which are passed over by the extensible follower, which is capable of giving more or less play to the action of the tool. The carriage which holds the forms and the shoes moves forward automatically in the direction of the fibers of the wood. After the external shaping (which takes ten minutes to a quarter of an hour) is finished, the shoe is put into a machine for hollowing out the heel and open part. For effecting this operation Mr. Arbey has made a special application of his vertical mortising machine, in which the bit is given the high rotary velocity of about 2,000 to 2,500 revolutions. The form of the bit was the object of numerous experiments, but the one finally adopted was the cylindrical quill bit.

The workman who regulates the operation of this machine controls the action of the bit by means of a pedal connected to the tool-carrier by a counterpoised lever, and causes the carriage, by means of two rods with handles, to move backward and forward over a space limited by a vertical follower which follows the internal contours of a model shoe made of cast iron. A small blower, fixed to the machine and actuated by a belt, keeps continually blowing the drillings away from the work. The opening having been made in the back part of the shoe, the latter is finally put into a special machine designed to hollow out the front of two shoes simultaneously. The two shoes, as shown in Fig. 2, are held vertically between a sliding puppet and a cast iron rest; and the two, as well as the cast iron model, are set in frames controlled by a lever at the top of the machine. These three frames move together, along with their carriage support and its regulating screw, on a swivel joint. The objects to be shaped can thus be brought into contact with the very rapidly rotating vertical cutters which are located on either side of a guide of the same shape. The latter, during the operation of the machine, regulates the action of the tools, and, by a slight resistance inside the model, notifies the workmen that the cutting edges have performed their work. In this manner as perfect a hollowing of the shoe is effected as if the work had been performed by an experienced maker of wooden shoes.

All the objects thus prepared pass for a second time under the band saw in order to have the small projecting piece removed from each extremity, and to form the plane surface and the sharp edge of the toe.

The five machines necessary for the operation of making these shoes require a motive power of six to eight horses, and a space of about 100 meters. The amount of production may be estimated at 180 pairs per day.

Each machine requires one workman. Besides these, six more operators are necessary for giving a complete finish to the shoes, and about three men for various other purposes connected with the manufacture.

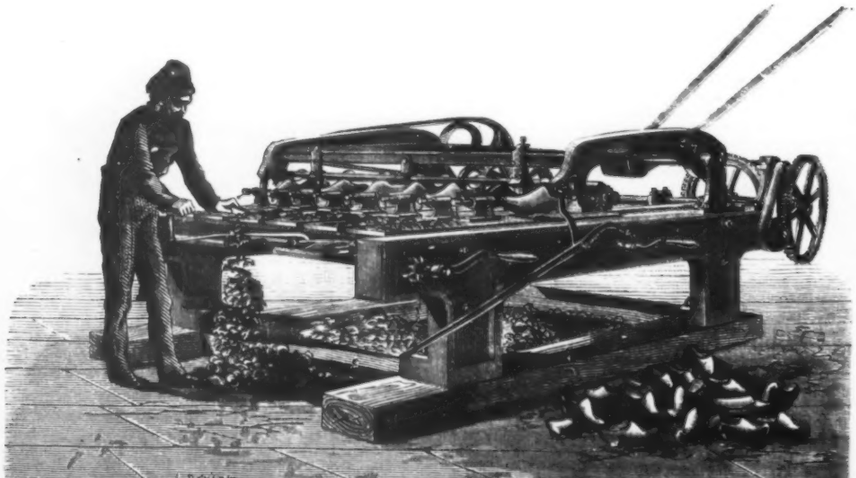


FIG. 3.—MACHINE FOR SHAPING SIX SHOES SIMULTANEOUSLY.

FINISHED CALFSKINS.

THE improvements made in the tanning of calfskins in this country during the past ten years have been very gratifying to those who have the interests of American leather at heart and wish to elevate its standard. They have also resulted in pecuniary benefit to the trade, as increased proficiency in tanning has resulted in enhanced values, until now the finest domestic skins range well up in price with the imported stock. Our best tannages still are not quite equal in quality to the leading French and German brands, and it is to overcome this difference that every American tanner should devote his energies.

There were in the United States, according to the census of 1880, something more than 13,000,000 milch cows kept for dairy purposes. The greatest number of these are in New York, Pennsylvania, and Iowa. These cows should drop ten millions of calves a year, three-quarters of them, at least, going to the butcher. This occupation does not include herds kept for breeding purposes. These dairy calves afford the best skins used for tanning purposes, and it is only by starting with such that fine, high-grade calfskins can be produced.

The best European calfskin tanners engage their stock from the butchers at least a year ahead. They are taken off and cured expressly for them. They are mostly folded on the back, being dried without salt. Great pains are taken to get skins of calves which have never tasted grass. They are killed at from one to six months of age. The best skins are taken off by merely blowing up the pelt and pressing the thumb against the hide. The pack of skins are as nearly uniform in weight and substance as possible. When they get to the tanner he sorts them still more closely, separating, in many cases, male from female skins, and then they are packed away in cool lofts to await the tanning processes.

The bark used by European tanners is oak, and it is taken off and prepared much more carefully than we are in the habit of doing it. The coppice oak, from small trees, is used; the bark is kept very clean and free from dirt or gum. By using plenty of it, and taking six or eight months time in tanning, they get good weights, bright color, and a fine feel in the skins.

After coloring and handling, the French process is to lay skins away paired grain to grain, for twenty to forty days, and they get four or five layaways in this manner with fresh bark and liquor of increased strength. The skins tan from the fresh side and have a grain smooth, tough, and of a delicate color.

Another point which gives excellence to foreign skins is the stuffing process. Only the best materials are used. Palm oil, castor oil, cotton seed oil, degras, and sod oil with tallow are worked thoroughly into the skins, and then after they are stuffed and dried they are packed down in piles of two or three hundred, and lie there for months, and even years, for they improve all the time. The European calfskin tanners carry very large stocks of goods, but they carry them "in stuff," and finish them as the demand requires.

It is by exercising such care with the skins in every process of the manufacture that French and German tanners are enabled to send calfskins to this country, and sell them

for $1.50 to $2 a pound. They use the same kind of skins, the same tanning materials, similar processes of tanning and finishing, but simply by exercising more care and attention to detail, are enabled to get an advance over prices of most of our domestic skins of from 50 to 72 per cent. This disparity ought not to continue.—*Shoe and Leather Reporter.*

COTTON SEED OIL MANUFACTURE.

ITS HISTORY AND PROGRESS.

THE following extracts, taken from a paper read before the Southern Underwriters' Association, at Atlanta, Ga., May 26, 1880, by Mr. Henry V. Ogden, of New Orleans, La., show that the manufacture of oil from cotton seed is not a new enterprise. He says:

"There is every reason to believe that the first move toward the extraction of oil from cotton seed was made at Natchez, Miss., in the year 1834. So far as we have been able to ascertain, the great honor of this first attempt belongs to Messrs. James Hamilton Couper and Samuel Plummer, of Georgia, and associated with them were Mr. Follett, of Norfolk, Va., and Major Anderson Miller, of Louisville, Ky. The late Archibald Dunbar, and other prominent citizens of Mississippi, invested liberally of their means, and shared the pecuniary loss that followed. The few who remember Mr. Couper speak of him as a man wonderfully gifted in general intelligence and business capacity. His large resources gave an impulse to the enterprise, and resulted in the putting up of the first mil' and machinery. In every respect, so far as known, the attempt was a disastrous failure. . . . When you are told that in this first mill the pressure to extract the oil was obtained from the simple wedge principle, you can easily imagine how rude and inadequate to success were all the other appliances.

"In the year 1852, just eighteen years later, it attracted the attention of Wm. Wilbur and Frederick Goode, citizens of New Orleans. These gentlemen, as strong in their faith in the original idea as their predecessors had been, embarked their all in a new attempt to give it practical value, and they conceived and carried out the plan of a mill, machinery, and process of extraction, crude and imperfect, perhaps, but still a great improvement over the Natchez mill of 1834, and which has been the inspiration of much that has followed. Their improvements enabled them to make oil and clarify it; they made the first soap and sold the first oil cake, but they did so only to share the fate of their predecessors of 1834, for like them, they were pecuniarily ruined. They had, however, succeeded far enough to convince themselves, and demonstrate to others, the possibility of the industry.

"In the year 1855, Mr. C. W. Bradbury, of New Orleans, engaged in the enterprise. Energetic and intelligent, he was notably the first to demonstrate beyond any question the feasibility of the manufacture. Laboring under many disadvantages, not the least of them the lack of capital necessary to efficiently carry out his own ideas of the business, he was unfortunately obliged to suspend operations for the time being, resuming again under better auspices only to be interrupted and ruined by the breaking out of the civil war."

Messrs. Paulin Martin, F. M. Fisk, Paul Aldige, and A. A. Maginnis, of New Orleans, engaged in the business, and were also interrupted in its successful prosecution by the war.

In 1855 a mill was established in Cincinnati and successfully operated. Capt. Jackson Warner, who was an agent for the purchase of seed for this mill, says that on visiting the farm of Mr. Joseph Davis, of Mississippi, for the purchase of seed, his attention was called to the dwelling of Mr. Davis, which was handsomely painted twenty years before with paint in which cotton seed oil was used. Mr. Davis told him that the oil was expressed on his farm by machinery in which the power was obtained by the use of the wedge. It was used at Athens, Ga., for the same purpose by Dr. Camak.

These facts are to-day of special interest as showing that the extraction of oil from cotton seed is not a new industry, though, as is the case with many new enterprises, the first attempts were not crowned with success.

PRODUCTS OF THE OIL MILLS.

The first step in preparing the seed for the mill is the removal of the lint left by the gin. This is done by a gin constructed for the purpose, with saws closer together than in the ordinary cotton gin. An average of twenty-two lb. of short lint is taken from a ton of the seed. This product, called "linters," brings, on the market, 6½ to 7 cents per lb., and is used in the manufacture of cotton batting.

The next product is the hulls, which are removed from the kernel and used as fuel for the engines which furnish the power for the mills. The hulls constitute about half the total weight of the seed. From their combustion results two qualities of ashes, averaging in price at the mill $12.00 per ton.

The mills average a yield of thirty-five gallons of crude oil to the ton of seed, which wholesales at the mills at 35 cents per gallon. This loses in the process of refining eighteen per cent.—so that the yield in refined oil is 28·70 gallons. The refined oil sells at the mills at 55c. to 60c. per gallon.

A ton of the seed yields, after extracting the oil, 700 lb. of oil cake or cotton seed meal, which is simply the cake ground. The cake or meal at present sells at the mills at $30.00 per ton. The average consumption of the mills is about 6,000 tons each per annum. The mills generally operate only about six months in the year, and hence their average capacity is 12,000 tons per annum. The consumption is, therefore, 350,000 tons per annum, with a capacity for twice that amount.

There are fifty-seven oil mills now in operation or being constructed in the South and along the Mississippi River, distributed as follows: 10 in Tennessee, 9 each in Mississippi, Louisiana, and Texas, 8 in Arkansas, 6 in Alabama, 2 in Georgia, 2 in Missouri, and one each in South Carolina and Illinois.

In 1880, 6 997,796 gallons of cotton seed oil were exported from the United States, while only 38,431 gallons of linseed oil were exported during the same year.

During the same year, 453,023,225 pounds of oil cake were exported. Taking the comparative quantities of cotton seed oil and linseed oil exported as an index of the comparative quantities of cake exported, and it will be seen that nearly the whole of this exported cake was from cotton seed.

Mr. Ogden says cotton seed oil "is the basis of nitro-glycerine and of various other explosive compounds. Cotton seed oil is the best material known for making glycerine. One gallon of crude oil returns three and one-half pounds of pure glycerine."

It will no doubt surprise many readers to learn that in 1878, 16,757,634 pounds of cotton seed were exported; in 1879, 16,397,938 pounds; and in 1880, 12,142,137 pounds. On this subject, Mr. Ogden remarks: "It is alleged that in France methods have been discovered for procuring a valuable blue dyestuff from cotton seed."

The 57 mills now in operation or being constructed will consume an average of 6,000 tons of seed per annum, running half the year. They have a capacity of 12,000 tons each. Assuming 6,000 tons as the average consumption, and we find that 342,000 tons are now used by the oil mills per annum. These cost at the mills ten dollars per ton, or an aggregate of $3 420,000.

They yield 35 gallons of crude oil per ton, or 11,970,000 gallons, which sells at the mills at 35 cents per gallon. The annual oil product, therefore, of the 57 mills will be worth $4 189,500.

The seed are reginned at the large mills, and 22 pounds of short lint per ton, called linters, yielded. These bring 6¾ cents to 7 cents per pound. The yield of linters from 342,000 tons of seed is, therefore, 7,524,000 pounds, which, at 7 cents per pound, is worth $526,680.

Each ton of seed yields 700 pounds of cake, which sells at one cent per pound at the mills. 342,000 tons of seed would, therefore, yield $2,394,000 worth of cake. The annual product of the 57 mills running half the year will, therefore, be as follows:

7,524,000 lb. linters, at 7c. per lb.	$526,680
11,970,000 gallons crude oil, at 35c. per gallon	4,189,500
239,400,000 lb. cake, at 1c. per lb.	2,394,000
Total	$7,110,180
Deduct cost of the seed	3,420,000
And we have values added by the mills	$3,690,180

The 342,000 tons of cotton seed consumed by the mills yield 171,000 tons of hulls, which are burned in the engines, and supply the fuel necessary to run the machinery. Each ton of hulls yields 70 lb. of ashes, which are very rich in potash.

As the oil is valueless as a fertilizer, every gallon extracted from the seed is so much clear gain. All that is valuable as a fertilizer in the seed is found in the cake and in the ash of the hulls. The $4,189,500 received for the oil, and $526,680 received for the "linters," thus come from products that are ordinarily wasted.

For convenience of calculation (and it is not likely to be less in the future), a crop of 6,000,000 bales is taken as the basis of the following estimates:

Assuming that the bales average 450 lb. each, their production involves the production of 2,700,000 tons of seed, estimating 900 lb. seed to the bale, or two of seed to one of lint.

According to the census of 1880, 14,462,431 acres were planted in cotton; allowing two bushels per acre for planting this area, 28,924,862 bushels, or 432,872 tons, of seed are required for that purpose.

Deduct this quantity from the whole amount produced, and there remain 2,266,128 tons of seed to be utilized as manure or stock feed. Supposing the whole of these to be used by the oil mills, and the following analysis of the products will not be devoid of interest. While it is not now practicable to so utilize them on account of the difficulty of transporting them to the mills, the day is not far distant when nearly, if not all, the crop will be so utilized.

The 2,266,128 tons of seed will yield, at 22 lb. per ton, 49,854,816 lb. of "linters," which at 7c. per lb., will bring $3,489,837.12.

The same seed will yield thirty-five gallons of crude oil per ton, or 79,314,480 gallons of oil, which sells at 35c. per gallon at the mill. From this, therefore, will be realized $27,760,068, which, as the seed are generally used, is entirely wasted, since the oil adds nothing to the value of the seed as a fertilizer.

The same seed will yield 700 lb. of cake per ton of seed, or 1,586,289,600 lb., which, at $20.00 per ton, will be worth $15,862,883.

From the hulls of each ton of seed 35 lb. of ashes are obtained, or 79,314,480 lb. of ashes, which are worth at the mill an average of $12.00 per ton, or $475,904.

The account with the seed under the supposition that the whole crop, except enough to plant, are utilized for the extraction of the oil, will stand about as follows:

From 2,266,128 tons of seed the mills will turn out—

49,854,816 lb. "linters," at 7c.	$3,489,837
79,314,480 gallons crude oil, at 35c.	27,760 068
793,144 tons oil cake, at $20.00	15,862,880
39,657 tons ashes, at $12.00	475,904
Total value of products	$47,588,689
2,266,128 tons seed, at $10.00 per ton	22,661,280
Increase of value by manipulation in the oil mills	$24,917,409

It will be seen, therefore, that the value of the crop of cotton seed of the Southern States is increased by the manipulation of the oil mills $24,917,409, and that this increase is greater by more than $2,000,000 than the marketable value of the seed in their original form. It will be observed also, that the value of the crude oil is more than $3,000,000 greater than that of the whole seed from which it is extracted, previous to such manipulation.

COST OF MILLS.*

The principal obstacle in the way of the general utilization of the crop of cotton seed is the cost of mill and machinery necessary to extract the oil. No doubt this will be remedied in time, but at the present stage of the industry, those who have had experience in the matter agree that a capital of at least $30.000 is necessary to establish and conduct an oil mill successfully. They agree that a mill with four presses, carrying six boxes each, is the smallest that will pay. The machinery required for such a mill embrace a 50 horse power engine, four presses, six heaters, two linters, with hullers, crushers, mats, elevators, conveyors, vats, mills for grinding the cake, etc., all of which will cost about $20,000. The buildings necessary are one or two stories, about 40x60 feet, and a seed room 60x100 feet. These will cost according to character and locality. Another difficulty lies in the uncertainty of securing a sufficient quantity of seed to keep the machinery running a reasonable number of months in the year. At present few of the mills run more than six months. As the business becomes more firmly established and the products become more generally used, there will be less difficulty in procuring the seed, and better prices realized by the farmer for them, and greater profits made by the mill men.

The refined oil is being rapidly introduced into general use for various purposes, including its substitution, when highly refined, for olive oil on our tables, as well as the use of a grade lower as a substitute for lard. Its entire substitution for the latter seems not improbable, for the reason that it is more delicate, involves less risk of injury to health, is cheaper, and keeps sweet longer. Very few who once try it return to the use of lard. It is equally as good as lard for any purpose for which the latter is used, and for many purposes far superior to it.

* For much valuable information connected with the manufacture of cotton seed oil, I am indebted to Col. Geo. W. Scott, Atlanta, Ga.

THE COTTON SEED CROP OF GEORGIA.

According to the returns of the tenth United States census, 2,617,138 acres were planted in cotton in 1879. On this area, 814,441 bales of cotton were produced. Each of these bales represents 900 pounds cotton seed. The production of the State was, therefore, 366,498 tons. Allowing two bushels per acre for planting, 78,464 tons were required for the purpose. Deducting this quantity from the whole number produced in the State—366,498 less 78,464—and 288,034 tons remain for use as manure or for feeding stock. These, at 15c. per ton, or $10.00 per ton, are worth $2 880,340.

The oil that may be extracted from the same number of tons of seed would sell for $3,528,416; the linters from the same, $443,572; the oil cake or meal from the same, $2,016,240; and the ash from the hulls, $60,480.

The account would stand as follows, if the whole surplus crop of seed produced in the State, after reserving enough to plant:

6,836,748 lb. "linters," at 7c.	$443,752
10,081,190 gallons oil, at 35c.	3,528,416
100,812 tons cake, at $20.	2,016,240
5,040 tons ashes, at $12.00	60,480
Aggregate value of products	$6,048,708
Value of seed unmanipulated, $10.00 per ton	4,880,340
Value added by manipulation of mills	$3,168,368

While it would be bad policy for farmers to part with their seed without replacing them with their equivalent in manurial value, it will be seen by the above statement that the mills can afford to take the seed from the plantation and return the cake or meal and ash without cost to the planter. This is plainly shown by the following analysis of the above figures. Under the present plan of purchasing the seed at $10.00 per ton, the mills would pay for the surplus crop of seed of Georgia after reserving two bushels per acre for planting, $2,880,340. From these they get $3,528,416 worth of crude oil, estimating it at the selling price at the mills, $443,572 worth of linters, $2,016,240 worth of cake, and $60.480 worth of ash from the hull.

The oil and linters, which would be wasted if the seed were used whole as manure on the farm, are worth at the mill $3,971,988, and the cake and ash together are worth $2,076,720. Now, supposing the planter exchanges his seed for the cake and ash, the mill men paying all expenses of seed and cake or meal and ash both ways, he loses nothing of value as a fertilizer, and gets his meal and ash in a form easily applied and readily assimilable by the plant; the mill men get the oil and linters to pay for their trouble and expense. They get $3,971,988 worth of oil and linters, and return to the planters $2,076,720 worth of meal and ash, leaving $1,885,268 profit, less freight on seed and cake. If they buy the seed at $10 per ton at the gin-house, and keep oil, cake, linters, and ash, they clear $3,168,368, less freights on seed and running expenses. This indicates that a better price might be paid for the seed than is now received by the planter. Some of the Western mills are paying $13 per ton for the seed, and offering to exchange 1,000 lbs. of meal for a ton of seed. They can well afford to pay $15 per ton for seed, and still make a very heavy profit.

Three qualities of soap made from cotton seed oil, crude and refined, and from the residuum of the manufacture, have been presented by Mr. Geo. T. Lewis, of Philadelphia, through Dr. N. A. Pratt, of Atlanta. These soaps were made in 1848. They are very neat and well preserved. Messrs. Lewis, of Philadelphia, make oil from seed procured from the Butler estate in Georgia in 1848, with remarkable results as regards the yield per bushel. They got an average of nearly a gallon of oil to the bushel of seed, while the average obtained now is only a little more than half a gallon per bushel. The difference is due, probably, to the fact that the seed used by Messrs. Lewis was of the sea island or black seed variety. They did not decorticate the seed, and used the old fashioned wedge press.

Experiments were made at the same time with the meal as food for cattle, with, to them, satisfactory results. They fed as much as three pecks of the cotton seed cake meal per day to cattle—more than one would dare to feed of modern meal. Samples of oil in this office, received from Mr. Geo. T. Lewis, appear to be equally clear as the modern article. The crude oil of the manufacture of 1848 is dark, but the refined is apparently very nice.—*Georgia Agricultural Report.*

PHOTO ITEMS.

At the weekly meeting of photographers held at Ashley's Hotel, on the 22d February, Mr. J. A. Harrison occupied the chair.

Mr. A. J. Brown read a paper on the so-called grease spots formed upon emulsion plates, and produced plates coated with emulsion containing a considerable quantity of added grease, in disproof of the theory that grease had anything to do with the spots at all.

Mr. A. L. Henderson said that Mr. J. Thomson, who was formerly much engaged in the manufacture of emulsion, had said that these spots were caused by using mixed gelatine. He (Mr. Henderson) thought that they were caused by particles of a harder gelatine among the mass of a softer kind. All gelatines sold contained not one form of gelatine only, but a mixture of several.

Mr. W. E. Debenham thought the practical investigation of the subject by the author of the paper most useful and decisive. His own experiments, by means of washing both sheet and liquid gelatine with ether, had long ago brought him to the same conclusion as that of Mr. Brown, namely, that grease was not the cause of the spots in question.

Mr. Mackie produced some negatives on plates that had been long kept. These negatives were covered, especially at the edges, with a smoky, iridescent stain.

Mr. Reiman said that he had found such stains to be superficial, and that they might be rubbed away.

Mr. Debenham said he believed they were caused by the action of gas and its products upon the plate. He had no-

ticed similar stains come very strongly upon plates which had been kept for a few weeks only in a room in which gas was always burning.

Mr. Ashman stated that he has found the intensity of gelatine negatives might be considerably reduced by bringing them into the light while covered with hypo.

Mr. Mackie observed that the same effect was produced when a negative fresh from the hypo was "stood" upon a shelf for a time to drain, whereas, if left immersed in the solution, no perceptible change took place.

A question from the box was read: "How can a silver print, already fixed, be toned?"

Mr. Henderson said that the usual acetate toning process could not in such a case be employed, but that the old toning process of mixed gold and hypo could.

Mr. Debenham said that the beautiful photographs of the 1862 exhibition, by Mr. W. England, were, he understood, toned thus: The prints were first fixed in new hypo, and then immersed in the gold and hypo solution until the desired color was obtained.

A print from which the albumen had separated in patches was produced, and the question was asked: "What is the cause of this separation?"

Mr. Ashman thought it was abrasion in washing; but others present considered it was due to a chemical condition of the paper or nitrate bath.

A question was read: "Does any one know anything of Moryson's intensifier?"

Mr. Henderson said he believed it was Monckhoven's cyanide of silver process, but he would have more to say on the subject at the next meeting.

Mr. W. Coles said that in using this process he did not consider it necessary to employ the pure cyanide, but with the ordinary commercial make a larger quantity was required to redissolve the precipitated silver.

Mr. A. Haddon exhibited a holder consisting of a sort of perforated basket for chloride of calcium when used in a drying room. A saucer was attached into which the liquefied chloride ran, and thus fresh absorptive surface was always presented to the air from which the moisture had to be removed.

ON THE INTENSIFICATION OF GELATINE NEGATIVES OR POSITIVES WITH SILVER.*

TOWARD the close of the past year I was asked by a friend to make him a series of lantern transparencies from a number of photographs and engravings with which he provided me. As I have for a long time past worked exclusively with gelatine plates I had no choice of a process by which to do them. With me it was a case of either gelatine or nothing. Unfortunately, in my hands at least, gelatine transparencies are rarely entirely satisfactory. The faults I have to find with them are that they are apt to be too thin and of bad color. If an attempt be made to overcome these objectionable qualities by pushing the development, the lights of the picture are almost sure to suffer, and if recourse be had to silver intensification (at least by any of the published methods) matters are often rendered worse rather than better, owing to the difficulty there is of avoiding staining or veiling, more or less, what ought to be the clear portions of the picture.

As I had plenty of time allowed me for the work, I tried a number of experiments in order to find out, if possible, some means of overcoming the above-mentioned difficulties; and I have at last hit upon a method of working which, though differing only very slightly from the usual plan of proceeding, yields me results incomparably better than any I have hitherto been able to obtain.

The following are the baths and solutions which I use:

1.—*Iodine Solution.*

Iodide of potassium	2 drachms.
Iodine	1 drachm.
Water	3 ounces.

2.

Nitrate of silver	20 grains.
Distilled water	1 ounce.

3.—*Iodine Bath.*

Alum	2 ounces.
Hydrochloric acid	2 drachms.
Iodine solution	1 drachm.

Dissolve the alum in hot water, and then add the acid and the iodine solution.

4.—*Iron Bath.*

Sulphate of iron	2 drachms.
Citric acid	2 "
Glacial acetic acid	1 drachm.
Alcohol	1 ounce.
Water	9 ounces.

Dissolve the iron and the citric acid in hot water, and then add the alcohol and acetic acid.

As this bath improves very much with age it will be found a good plan to mix two bottles of it, one of which must be used as the stock bottle and kept constantly filled from the other, and when this second bottle is empty a fresh supply must be made.

The iodine bath undoubtedly deteriorates with use, and must consequently be renewed from time to time. Having prepared the above solutions, the following is the way in which they are to be applied. But first let me say that the intensification may be proceeded with while the picture is still wet, either before or after fixing, or after it has been allowed to become dry, and each of these methods has its own peculiar advantages. Should the plates be rather too thin and transparent, it will be better to intensify before fixing, because density can be more easily obtained at this time; but with thick, opaque films, such as are now generally used, the operation is best performed after fixing, because the effect can then be so much better seen and judged. Should, however, the plate be at all inclined to frill, it will then be necessary to defer the intensification till after it has become dry, because when once it is dry all danger from frilling will cease.

And now let me suppose that it is desired to intensify a picture after fixing, as this is the case that will most generally occur. The following is the plan of procedure: After removing the plate from the hypo bath, wash it thoroughly for four or five minutes in several changes of water; then, having poured a portion of the iodine bath into a flat dish, plunge the plate into it. Rock the dish gently for about half-a-minute, after which remove the plate to a dish of water, wash for about a minute in three changes of water, and it will now be ready for the iron bath.

In all the printed instructions for applying this which I have seen, one or other of two methods is invariably prescribed. The first is to pour a little of the iron solution into a flat dish, add a few drops of a solution of nitrate of silver, and then plunge in the plate. This having been done, observe what takes place. Unless the dish be chemically clean—a not too easy state of things to bring about—the silver will expend its energies in blackening it, and will finally convert the solution into a muddy mess, which, if the operator be not very careful, will cause a deposit to settle on the film and ruin the negative. The other plan is this: Having attached the plate to a pneumatic holder, pour the solution on and off from a developing cup until the required density is obtained. This may appear a delightfully simple operation in theory, but in practice it is quite the reverse, because a gelatine film is so repellent that it is almost impossible to get an aqueous solution to lie nicely upon it. Fortunately both these difficulties may be entirely avoided in the following way: Pour a portion of the iron solution into a flat dish, and in this immerse the plate. Next pour into a developing cup a little of the same solution, and from ten to twenty drops of the nitrate of silver solution; for a 5 × 4 plate two drachms will be sufficient. Now take the plate out of the dish, and holding it either by one corner with the fingers or on a pneumatic holder, immediately pour over it the contents of the cup. The solution will flow up to the extreme edges of the plate, which may now be kept evenly covered without the slightest difficulty.

Should the picture only require a little additional density this will be quickly obtained; but if, on the contrary, it be much too thin, it will gain strength very slowly, and the operator will require to use all his patience and a liberal allowance of silver as well, to obtain what he seeks, and, possibly, be obliged to resort to mercury to finish with. But, even in this case, the previous treatment with silver will not have been wasted, as it will furnish a foundation for the mercury to build upon, and it will now be easy to gain an amount of density which the mercury alone would not have given. Should the intensifier become turbid in the course of the operation it must be immediately rejected, and the plate flushed with a small quantity of the iron solution, but on no account with water. The intensification may then be continued with a fresh portion of the iron and silver solutions. As soon as the operation is completed the plate must be washed until the water will lie smoothly upon it, and then be plunged a second time in the hypo bath, in which it should be allowed to remain for about a minute, after which it may be removed to a dish of water and washed in the usual way.

Before closing these remarks I feel as if a word of apology were due from me for having occupied the time of the meeting with a matter which most of you may consider trivial and, possibly, not new. My excuse is that I certainly had no intention to have done so, and I should have remained quietly in the dark had not our indefatigable hon. secretary most unexpectedly unearthed me and dragged me into light. —*H. Houlgrave, in Brit. Journ. of Photography.*

* A communication to the Liverpool Amateur Photographic Association.

APPARATUS FOR ELECTRICAL MEASUREMENTS.

IN a recent article on this subject I referred to some apparatus for measuring electricity that were, in the main, new, but left a description of them for a future occasion. I now return to the subject to describe them in detail. They include a *recharger* and an *electrical gauge*.

HUMBLOT'S MIXED ELECTROSTATIC MACHINE AND RECHARGER.

Everybody is familiar with Sir William Thomson's replenisher, a small electrostatic induction machine generally inclosed in the interior of his quadrant or absolute electrometers, which serves to maintain the potential of the needle or of a plate of the electrometer constant, and which is always joined in the interior of these apparatus to a gauge that serves for ascertaining the constancy of the potential.

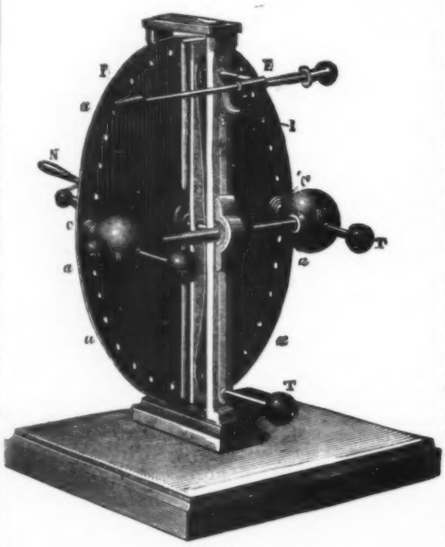


FIG 1

Now, such an arrangement possesses two inconveniences: (1.) It singularly complicates the construction of the electrometers, so as to make it impossible for experimenters to repair them, or regulate them anew, when they get out of order. (2.) It obliges observers to leave the experimental apparatus from time to time to put their eye to the lens of the gauge to see whether the potential remains constant, and to put the replenisher in motion if there is occasion to.

So, in certain simplified electrometers, like Mascart's, the gauge is done away with, and the needle is charged to a constant potential by the aid of a pile composed of a great number of Smee or Daniell elements. But here we have the trouble of taking care of a pile, and the electrical state of the galvanometer needle cannot be ascertained at every instant.

In order to avoid these inconveniences and to preserve the advantages of rechargers and the gauge, I have endeavored to place the indications of the gauge continuously before the eyes of the observer, and to put the recharger within his easy reach. At the same time, I have tried to ascertain whether it would not be possible to make a recharger or replenisher more energetic than that of Sir William Thomson, and I have been enabled to do so by having the author himself, Mr. Humblot, modify a small machine which he invented in 1870, and which since that time has been sold as a scientific plaything for children. In the first place, the following is a description of the machine, which is shown in Fig. 1:

P is a plate formed of two thin ebonite disks glued one to the other after previously applying to one of them a series of 20 or 24 small tinsel sectors. Each of these latter (invisible in the cut) carries a small appendage, *a*, *a*, *a*, which just reaches the surface. The plate revolves by means of a winch, N, around a horizontal axle. The latter traverses the two wooden uprights which support the apparatus and fix it to a rectangular tube, and it communicates with a transverse tube of thick glass, terminating in the balls, B and T. This tube is coated internally and externally with metal, so as to make it a sort of Leyden jar. The balls, B, which form a part of one of the armatures of this jar, carry spiral springs, C, C,

FIG. 2

of copper wire, which press against that part of the circumference of the plate that contains all the appendages, *a*, *a*, *a*.

On another hand, the second armature of the condensing tube communicates with the rubbers, F, which are arranged as in ordinary Ramsden electrical machines. A movable rod, E, communicating with the rubbers, causes the sparks re-enforced by condensation to leap between it and the balls, B. They may also be re-enforced by connecting one of the rods, T, fixed to the ball, B, with the rod, T, at the base of the upright, through the intermedium of tubes coated like small Leyden jars. Further, by the aid of a spring, I, the metallic circuit which joins the rubbers with the armature of the condensing tube may be broken, and sparks may be obtained at this point differing from those obtained by the aid of the rod, E.

The theory of the machine is evidently complex. On the one hand it resembles a Varley accumulator, and on the other it is a friction machine.

It is certain that friction electrifies the surface of the plate *directly;* but, at the same time, either through polarization of the molecules of the dielectric, or through induction from a distance, or through both causes united, the internal metallic sectors are electrified, and deposit their charge successively on the collecting spring, C, as a consequence of the rotation of the plate, and so charge one of the armatures of the condensing tube, B, while the opposite electricity of the rubbers charges the other armature. We have here, then, a *mixed* machine, in which the effects of friction, of induction, and very probably of the polarization of the dielectrics are united. The principal advantage of this arrangement, which is as simple as it is ingenious, resides, without doubt, in the fact that the electrified sectors are insulated during the time that they take to pass from the rubbers to the collectors, C, and deposit thereon nearly all the electricity that they have received. At all events, it is certain that, as regards equality of surface and velocity, these little machines give better results than all others.

In the second place—and this is an important point that I desire to bring out—this machine, provided it be kept clean (which is easily done by wiping it from time to time with a rag moistened with petroleum), works immediately without the necessity of warming it, and that, too, in any kind of weather. In practice this is a valuable advantage, and it is precisely this feature that led me to think of utilizing the machine as a recharger, by diminishing its dimensions and arranging it in such a way that it might charge or discharge a conductor put in connection with it.

It became necessary for this purpose to greatly simplify the machine so as no longer to give large quantities of electricity, but rather very small quantities as compared with the relatively high potential given by friction machines. It also became necessary to render the machine in some sort *reversible*, like the Thomson's replenisher, that is to say, capable of increasing or diminishing, according to the *direction* of rotation, the potential on a conductor in metallic communication with it.

The problem thus stated to Mr. Humblot, along with sufficient directions, was very simply solved by him as follows:

Fig. 2 represents a plate, P, like that of the preceding machine reduced to a diameter of a few (5 to 6) centimeters, movable by means of a button. At *l* is represented one of the internal sectors, whose appendage, *a*, in this case is at the external circumference of the plate, P. At *c* is a collecting spring that is to be connected to the conductor, which is to be raised to and maintained at a certain potential. The rubbers, which are represented at F, are in the shape of an inverted V. At 90° of the rubbers a spring, *r*, is in contact with the circumference of the plate.

The little machine is thus dissymmetrical, and it may be seen without any difficulty that, according to the direction of

rotation, the effect produced on the conductor connected to *a* will be different, and that it will be charged if the rotation takes place in a direction opposite to the motion of the hands of a watch, and be discharged gradually in the other direction. In fact, in the first case, each sector, *i*, electrified in its passage under the rubber will deposit its charge on the collector, *c*; and, in the second case, the electrified sector will come *first* in contact with the spring, *r*, and discharge itself, and will reach the collector in a neutral state, or nearly so, and will become charged in contact with it, thus consequently absorbing from the conductor in contact with it a little of its charge, which will afterwards be neutralized in contact with the spring, *r*.

FIG. 3.

Experience proves that effectively the instrument produces the same effect on an electrometer as Thomson's replenisher, and that it only takes a small fraction of a revolution of the plate to keep up from time to time the charge desired.

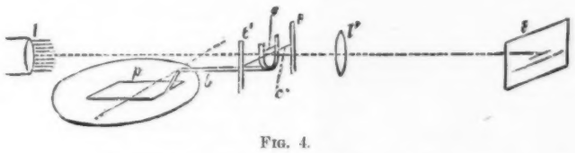


FIG. 4.

shall now show how the instrument may be practically arranged by adding to it a modified gauge.

ELECTRIC GAUGE.

In order that this gauge might be placed outside of electrometers it was necessary that it should be given proper conditions of insulation. Moreover, it became a question of, in some sort, transforming the indications of the instrument so as to project them to a distance of about a meter in order to put them constantly before the eyes of the observer.

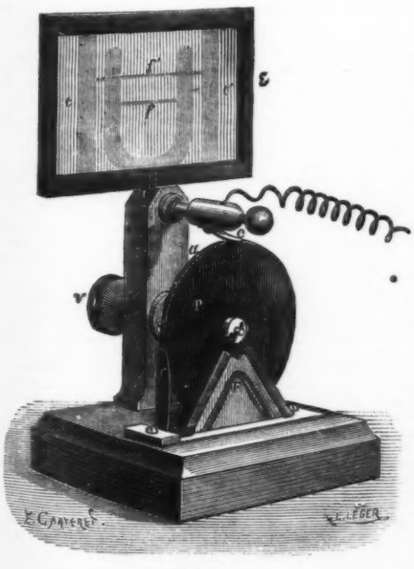


FIG. 5

To reach this double result, I had Mr. Charpentier construct the apparatus shown in Fig. 3. None of the essential parts of the Thomson gauge is here changed. In fact, there is seen at D the brass disk which is charged through the intermedium of the rod, T, and which attracts the aluminum plate, *p*, surrounded by its protecting ring, movable around a platinum wire, *f*. The weight of the plate, *p*, is balanced by the aluminum lever-arm, *b*, which carries the horizontal hair between two black points fixed on a small enameled rod in the Thomson apparatus. But here the latter *opaque* rod is replaced by two parallel rods, *t* and *t'*, between which is stretched a very fine rigid wire, *c*. Moreover, the arm, *b*, terminates in a horseshoe that carries a hair, *c*, parallel with the wire, *c'*, and as near to it as possible (within 1 or 2 millimeters), and raised 5 or 6 millimeters above the lever, *b*.

The result of this arrangement (shown clearly in the diagram, Fig. 4) is that, by means of a pencil of parallel rays emitted by a lens, *l*, the movable hair, *c*, and the fixed wire, *c'*, may be brightly illuminated; and that, by placing upon a support fixed to the gauge a lens, *l*, of proper focal length, a clear image of the hair and wire may be obtained on a screen at about a meter's distance from the apparatus.

The disk, D, being charged, the plate, *p*, is attracted, and the image of the hair, *c*, moves toward the fixed images of the wire, *c'*; and the coincidence of the two images corresponds to a determinate potential, which depends upon the construction of the instrument and upon the distance of the disk, D, from the movable plate, *p*.

In any case, it is only necessary to charge or discharge the disk, in such a way as to keep up the coincidence of the two images, in order to be certain of the constancy of the potential on the disk.

On referring to the figure it will be seen that the apparatus, properly called, is contained in a cylindrical glass case fixed to an ebonite disk, E, which is supported by three legs mounted on leveling screws. The air inside the case is kept constantly dry with sulphuric acid or quicklime.

The ebonite and glass are, moreover, covered with a thick coat of shellac varnish. The head of the screw, N, which serves to cause the disk to move, is insulated, as is the rod, T. With these precautions, the charge is sufficiently maintained under the gauge.

It must be remarked, however, that, from the moment the observer has before his eyes the indications of the instrument on the screen, E, and has within his reach the recharger to keep up the charge, it is no longer absolutely necessary, as with the Thomson apparatus, that the gauge should have to keep up its charge for several hours without being touched.

The relation between the gauge and recharger is established by the aid of a well insulated wire, which is fixed at one end to the rod, T, of the gauge, and at the other to the collecting spring, C, of the recharger (Fig. 5).

Fig. 5 gives a perspective view of the recharger, with its ebonite plate, P, its rubbers, F, and the button, *v*, for revolving it, and which is within reach of the operator. At E is seen the small plate of ground glass upon which are projected the images of the rods, *t*, *t'*, of the fixed wires, *f'*, of the movable hair, *f*, and of its support.

The observer is located behind the screen on the side with the button, *v*.

It goes without saying that the disk of the gauge is also connected by an insulated wire with the needles or dials of the electrometers, so that they may be charged at the same time, and kept at the same time at a constant potential.

E. MERCADIER.

TAN BARK IN EUROPE.—The demand for tan bark in Europe is urgent, but the price is not sufficient to make the exportation of bark in bulk profitable. It is now proposed to grind and compress the bark where it is abundant, and ship it in kegs or half barrels. For this work a steamer has been built on the Ohio, to be used on the upper waters of the Tennessee River, along whose shores tan bark is plentiful and cheap. The steamer carries special machinery for grinding and compressing the bark.

RECOMMENDATIONS OF THE LIGHTNING ROD CONFERENCE.

THE recently issued report of the Lightning Rod Conference, which was composed of delegates from the Meteorological Society, the Royal Institute of British Architects, the Physical Society, and the Society of Telegraph Engineers, is of international importance and of great interest to all owners of buildings supposed to be protected by lightning conductors. The subject matter is divided into three sections; (1) The purpose which a lightning rod is intended to serve; (2) a statement of disputed points in the construction and erection of lightning conductors, and the decision of the conference thereupon; and (3) a code of rules for the erection of lightning conductors. The minimum dimensions fixed by the conference are—copper: rope ½ in. diameter; round rod, ⅜ in.; tape ¾ + ⅛ in.; iron: round rod, ⅝ in. The weight of the latter will be 35 oz. to the foot, while none of the copper materials will exceed 7 oz. to the foot. The conference considers that in most cases copper is the cheapest and best material.

The lightning rod recommended by the conference has no terminal points, but the rod itself is carried to the full height required, and then simply beveled off. About a foot below the summit a copper ring is soldered, carrying three or four copper needles, 6 in. long, and tapering from ¼ in. diameter to as fine a point as possible, the points to be platinized, gilded, or nickel plated. The summit of the conductor will thus have the full electrical conductivity of the rod to receive a flash of lightning, while the points below will tend to promote the "silent discharge" as in the usual arrangement. In a great many cases it would be advisable to platinize or gild, rather than nickel plate the copper needles, for in large towns where coal is consumed, the moist sulphur gases in the coal smoke would be nearly certain to destroy the thin coating of metallic nickel sooner or later. Novel and definite recommendations are made as to the earth connection, which ought to have serious consideration from any one thinking of erecting a lightning conductor. Owing to want of sufficient data the conference makes no definite numerical estimate of the area protected by a lightning rod, but states that, except in two doubtful cases, there is no recorded instance of a building being struck within a conical space the radius of whose base is equal to its height. Examination and testing of conductors at intervals are insisted on as essential. A statement is made that a copper lightning conductor, one inch in diameter, having its base thoroughly connected with moist earth, may be clasped with impunity while the top of it receives a powerful flash of lightning; but, the assurance of the conference notwithstanding, most people would be somewhat diffident of trying this experiment.

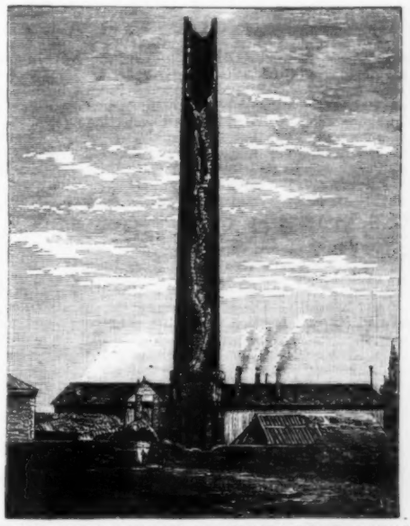
THE DISASTROUS EFFECTS OF LIGHTNING.

AT the termination of a very sudden squall, which traversed the British islands on the 20th of last December, a very heavy thunderstorm arose in the environs of Douay; and, during the progress of it the lightning struck a factory at Sin-le-Noble, causing certain havoc therewith worthy of description. The information that we publish was communicated to us by Mr. Paul Desmarest, the director of the Metereological Observatory at Douay.

The effects of the squall of the 20th of December were very sensibly felt in the North of France, and several times during the day the violent wind was accompanied in the environs of Douay by torrents of rain and hail. At ten o'clock at night the storm burst in its fury; and, half an hour later, there was heard a peal of thunder—one only, but violent, and this was accompanied by a very vivid flash of lightning.

The thunderbolt struck the chimney (150 feet in height) of Mr. Frevet's sugar refinery at Sin-le-Noble, completely uncapping it. It produced at the summit a wide cavity of about thirty feet in length, and then descending, opened a pretty deep and zigzag fissure all the way down. It afterwards carried away the gutter, covered the stokers with soot, traversed the different rooms, and extinguished the gas, and finally made its exit through a vent-hole and entered the earth. During its passage through the building it surrounded a workman with flames without doing him the least harm. Moreover, no person about the structure was in any way injured. The bolt broke the windows of a house in the vicinity. The accompanying cut, taken from a photograph, shows the state of the chimney after it was struck.

The havoc wrought by lightning is often terrific, and facts of the nature that we have given would scarcely appear credible at times, were they not reported by persons of veracity. Arago, in his notice on thunder, cites numerous examples. He states, for instance, that in 1762 lightning demolished the turret of a church at Cornouailles, and threw a stone weighing not less than 225 pounds to a distance of



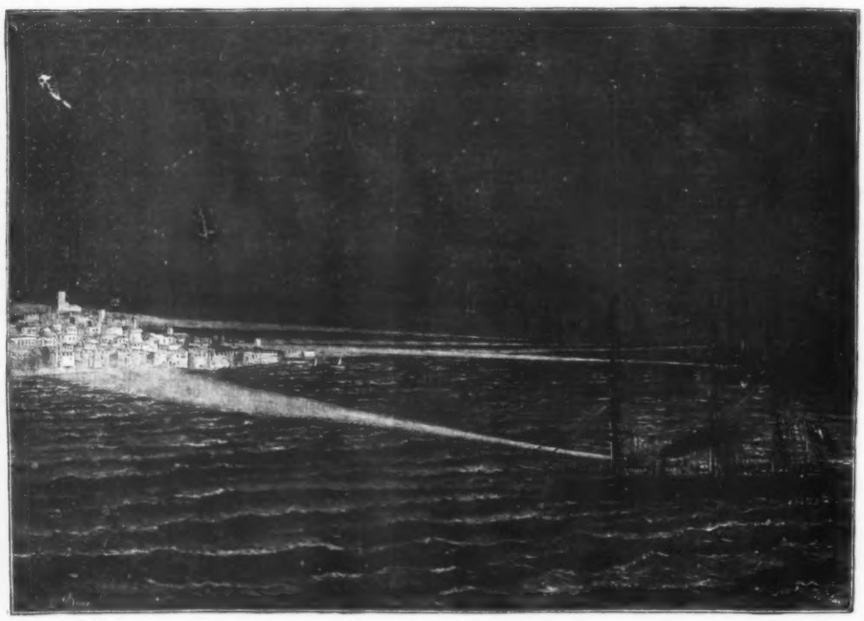
CHIMNEY STRUCK BY LIGHTNING NEAR DOUAY.

150 feet. At an epoch more recent (in 1809,) a wall near Manchester, weighing more than 26 tons, was lifted from its foundation and removed 9 feet at one of its extremities by a very violent thunderbolt.

In endeavoring to imitate certain effects of lightning, Priestley found that bodies situated near the point where a strong discharge takes place, may be suddenly displaced, and he succeeded thus in throwing pieces of wood to a distance of 10 or 15 centimeters. This illustrious physicist explained these phenomena as due to the disturbance of the air.—*L'Electrician.*

THE ELECTRIC LIGHT IN THE NAVY.

AMONG the applications of the electric light one of the most important is certainly that of the use of electric lamps in operations attending naval warfare. The great range of electric force, in fact, allows of the illumination at a distance of any point whatever, either of some position of the enemy that it is desirable to watch, or of a portion of the shore where a landing is being made; and the importance of having a light of wide range for such purposes will be readily appreciated. For this reason the Minister of the Navy has occupied himself for some years with this question, and has caused the naval engineers to undertake some experiments with the object of ascertaining the best lamp to employ in ships, the source of the current being readily found in any of the ordinary dynamo-electric machines, actuated by the ship's steam engine. Notwithstanding the improvements introduced into the different regulators, and particularly into the Serrin regulator, which has been so modified by its inventor as to make it possible to operate it in all possible positions the committee on experiments has thrown out every species of this kind of apparatus and has pronounced itself in favor of a hand lamp in which the carbons are made to approach each other by means of a screw maneuvered by the person who has the apparatus in charge. As a surveillance of the lamp is necessary in order to keep the direction of the luminous rays constant, there is no disadvantage in not having the carbons work automatically. The reflector



ELECTRIC ILLUMINATION OF SOUSSE DURING ITS OCCUPATION.

that has been adopted is, as well known, the Mangin projector the use of which is now pretty general.

In the figure hereto annexed is shown the application of these electric apparatus for illuminating the city of Sousse at the time of its occupation. It is well known what services were rendered at that epoch by the use of the electric light on ships of war; and everything leads to the belief that its applications will still further extend, not only for naval purposes, but also for those of the merchant marine.

THE SYNTHESIS OF ORGANIC COMPOUNDS BY ELECTROLYSIS.

By A. BARTOLI and G. PAPASOGLI.

IF a piece of carbon be suspended in water and be made to act as the positive pole of a strong current, it will be consumed with the formation of carbon dioxide, carbon monoxide, mellitic acid, and hydromellitic acid. In alkaline (but not in an acid) solution a body was formed composed of carbon, hydrogen, and oxygen, to which the name of mellogen is proposed by the authors. It is solid, amorphous, pulverulent, infusible, and soluble in hot water. It differs from the ulmine compounds although it has some analogies with them, by very readily taking up oxygen and forming mellitic acid, even at ordinary temperatures.—*Gaz. Chim.* ii., 468

This new formation of mellitic acid from carbon is very interesting. As is well known, this acid may also be produced by oxidizing the different varieties of carbon, excepting the diamond, with nitro-sulphuric acid. This fact, and also the production of numerous aromatic compounds by dry distillation, are adapted to throw some new light on the carbon molecule.—*Note by Editor Chem. Zeitung*, vi.,7. M. B.

QUANTITATIVE ESTIMATION OF CHLORIC ACID.—Instead of the tinfoil, recommended by Thope and Eccles, which, with copper sulphate, reduces the chloric acid, Fr. Becker advises the use of zinc dust.—*Chem. Zeitung*, vi., 189. M. B.

SOLIDS, LIQUIDS, AND GASES.

By W. MATTIEU WILLIAMS.

PART I.

THE growth of accurate knowledge is continually narrowing, and often obliterating the broad lines of distinction that have been drawn between different classes of things. I well remember when our best naturalists regarded their "species" of plants and animals as fundamental and as inviolable institutions, separated by well-defined boundaries that could not be crossed. Darwin has upset all this, and now we cannot even draw a clear, sharp line between the animal and vegetable kingdoms. The chemist is even crossing the boundary between these and the mineral kingdom, by refuting the once positive dictum that organic substances (*i. e.*, the compounds ordinarily formed in the course of vegetable or animal growth) could not be produced directly from dead matter by any chemical device. Many of such organic compounds have now been made in the laboratory from mineral materials.

We all know broadly what are the differences between solids, liquids, and gases, and, until lately, they have been very positively described as the three distinct states or modes of existence of matter. Mr. Crookes suggests a fourth. I will not discuss this at present, but merely consider the three old-fashioned claimants to distinctive existence.

A solid is usually defined as a body made up of particles which hold together rigidly or immovably, in contradistinction to a fluid, of which the particles move freely over each other. "Fluid" is the general term including both gases and liquids, both being alike as regards the mobility of their particles. At present, let us confine our attention to liquids and solids.

The theoretical or perfect fluid which is imagined by the mathematician as the basis of certain abstract reasonings has no actual existence. He assumes (and the assumption is legitimate and desirable, provided its imaginary character is always remembered) that the supposed particles move upon each other with perfect freedom, without any friction or other impediment; but, as a matter of fact, all fluids exert some amount of resistance to their own flowing; they are more or less *viscous*, have more or less of that sluggishness in their obedience to the law of finding their own level which we see so plainly displayed by treacle or castor oil.

This viscosity, added to the friction of the liquid against the solid on which it rests, or in which it is inclosed, may become, even in the case of water, a formidable obstacle to its flow. Thus, if we make a hole in the side of a tank at a depth of 16 feet below the surface, the water will spout from that hole at the rate of 32 feet per second, but if we connect with this hole a long horizontal pipe of the same internal diameter as the hole, and then observe the flow from the outlet of the pipe, we shall find its velocity measurably diminished, and we shall be greatly deceived if we make arrangements for carrying swift-flowing water thus to any great distances.

Three or four years ago an attempt was made to supersede the water-carts of London by laying down on each side of the road a horizontal pipe, perforated with a row of holes opening toward the horse-way. The water was to be turned on, and from these holes it was to jet out to the middle of the road from each side, and thus water it all. I watched the experiment made near the Bank of England. Instead of spouting across the road from all these holes, as it would have done from any *one* of them, it merely dribbled, the reason being that in order to supply them all, the water must run through the whole of the long pipe with considerable velocity, and the viscosity and friction to be overcome in doing this nearly exhausted the whole force of water-head pressure. Many other similar blunders have been made by those who have sought to convey water power to a distance by means of pipes of such diameter as should demand a rapid flow through a long pipe.

The resistance which water offers to the stroke of the swimmer or the pull of the rower is partly due to its viscosity, and partly to the uplifting or displacement of some of the water. If it were perfectly fluid, our movements within it, and those of fishes, etc., would be curiously different, and, in fact, the whole face of this globe would be strangely altered in many respects. I will not now follow up this idea, but leave it as a suggestion for the reader to work out for himself, by considering what would remain undone upon the earth if water flowed perfectly, without any internal resistance.

The degrees of approach to perfect fluidity vary greatly with different liquids.

Is there any such a thing as an absolute solid, or a body that has no degree of fluidity, the particles or parts of which will admit of no change of their relative positions, no movement upon each other without fracture of the mass? This would constitute perfect *rigidity*, or the opposite to *fluidity*.

Take a piece of copper or soft iron-wire, about one-eighth of an inch in diameter, or thereabouts, and bend it backward and forward a few times as rapidly as possible, but without breaking it; then, without loss of time, feel the portion that has been bent. It is hot—painfully so—if the experiment is smartly made. How may this be explained?

It is evident that in the act of bending there must have been a displacement of the relative positions of the particles of the metal, and the force demanded for the bending indicated their resistance to this movement upon each other; or, in other words, that there was friction between them, or something equivalent to such internal friction, and thus the mechanical force exerted in the bending was converted into heat-force.

Here, then, was fluidity, according to the above definition; not perfect fluidity, but fluidity attended with resistance to flow, or what we have agreed to call viscosity. But water also offers such resistance to flow or viscosity, therefore the difference between iron or copper-wire and liquid water as regards their fluidity is only a difference of degree, and not of kind; the demarkation between solids and liquids is not a broad, clearly-defined line, but a band of blending shade, the depths of tint representing varying degrees of viscosity.

PART II.

Multitudes of examples may be cited illustrating the viscosity of bodies that we usually regard as types of solidity, such, for example, as the rocks forming the earth's crust. In the "Black Country" of South Staffordshire, which is undermined by the great ten-yard coal-seam, cottages, chimney-shafts, and other buildings may be seen leaning over most grotesquely, houses split down the middle by the subsidence or inclination of one side, great hollows in fields, or across roads that were once flat, and a variety of other distortions, due to the sinking of the gradual rock-strata that have been undermined by the colliery workings. In some cases the rocks are split, but usually the subsidence is a gradual bending or flowing down of the rocks to fill up the vacuity, as water fills a hollow or "finds its own level."

I have seen many cases of the downward curvature of the roof of a coal-pit, and have been told that in some cases the surrounding pressure causes the floor to curve upward, but have not seen this.

As *Knowledge* will doubtless have many readers in the colliery districts, some of them may be able to supply reliable evidence of this, accompanied with careful measurement of the amount of upward curvature or upheaving in a stated breadth of road or working.

Earthquakes afford another example. The so-called solid crust of the earth is upheaved and cast into positive billows that wave away on all sides from the center of disturbance. The earth-billows of the great Lisbon earthquake of 1755 traveled to this country, and when they reached Loch Lomond were still of sufficient magnitude to raise and lower its banks through a perpendicular range of two feet four inches.

It is quite possible, or, I may say, probable, that there are tides of the earth as well as of the waters, and the subject has occupied much attention and raised some discussion among mathematicians. If the earth has a fluid center, and only a comparatively thin crust, as some suppose, there must be such tides produced by the gravitation of the moon and the sun.

Ice presents some interesting results of this viscosity. At a certain height, varying with latitude, aspect, etc., we reach "the snow line" of mountain slopes, above which the snow of winter remains unmelted during summer, and, in most cases, goes on accumulating. It soon loses its flocculent, flaky character, and becomes coherent, clear blue ice by the pressure of its own weight.

A rather complex theory has been propounded to explain this change—the theory of *regelation*—*i. e.*, refreezing, a theory which assumes that the pressure between the surfaces first thaws a film of ice at the surfaces of contact, and that presently this refreezes, and thus effects a heating or general solidification. Faraday found that two pieces of ice with moistened surfaces united if pressed together when at just about the temperature of freezing, but not if much colder. Tyndall has further illustrated this by taking fragments of ice and squeezing them in a mould, whereby they became a clear, transparent ball, or cake, and schoolboys did the like long before when snowballing with snow was about the thawing point. Such snow, as we all remember, became converted into stony lumps when firmly pressed together. We also remember that in much colder weather no such cohesion occurred, but our snowballs remained powdery in spite of all our squeezing.

I am a skeptic as regards regelation. I believe that the true explanation is much simpler; that the crystals of snow or fragments of ice in these experiments are simply welded, as the smith unites two pieces of iron, by merely pressing them together when they are near their melting point. Other metals and other fusible substances may be similarly welded, provided they soften or become sufficiently viscous before fusing. Platinum is a good example of this. It is infusible in ordinary furnaces, but becomes pasty before melting, and, therefore, one method adopted in the manufacture of platinum ingots or bars from the ore, is to precipitate a sort of platinum snow (spongy platinum) from its solution in acid, and then compress this metallic snow in red-hot steel moulds by means of pistons driven with great force. The flocculent metal thus becomes a solid, coherent mass, just as the flocculent ice became coherent ice in Tyndall's experiment or in making hard snowballs. Wax, pitch, resin, and all other solids that fuse, *gradually* cohere, are welded, or, in very plain language, "stick together" when near their fusing point.

I have made the following experiment to prove that when this so-called regelation of snow or ice fragments occurs, the ice is viscous or plastic, like wax or pitch. A strong iron squirt, with a cylindrical bore of half-an-inch in diameter, is fitted with an iron piston. This piston is driven forth by a screw working in a collar at one end of the squirt. Into the other end is screwed a brass nozzle with an aperture about

one-twentieth of an inch diameter, tapering or opening inward gradually to the half-inch bore.

Into this bore I place snow or fragments of ice, then hold ing the body of the squirt firmly in a vi-e, I work the lever of the screw, and thus drive forward the piston and crush down the snow or ice fragments, which presently become coherent and form a half-inch solid cylinder of clear ice. Applying still more pressure, this cylinder is forced like a liquid through the small orifice of the nozzle of the squirt, and jets or sprouts out as a thin stick of ice like vermicelli or the leads of "ever-pointed pencils," for the moulding of which the squirt was originally constructed.

I find that ice at 32° can thus be squirted more easily than beeswax of the same temperature, and such being the case, I see no reason for imagining any complex operation of regelation in the case of the ice, but merely regard the adhesion of two pieces of ice when pressed together as similar to the sticking together of two pieces of cobbler's-wax, or softened sealing wax or beeswax, or the welding of iron or glass when heated to their welding temperatures, *i. e.*, to a certain degree of incipient fluidity or viscosity.

If a leaden bullet be cut in half, and the two fresh-cut faces pressed forcibly together, they cohere at ordinary atmospheric temperatures, but we have no occasion for regelation here. The viscosity of the lead accounts for all. At Woolwich Arsenal there is a monster squirt, similar to my little one. This is charged with lead, and, by means of hydraulic pressure, the lead is squirted out of the nozzle as a cylindrical jet of any required diameter. This jet or stick of lead is the material of which the elongated cylindrical rifle bullets are now made.

But returning to the point at which we started, on the subject of ice, viz., its Alpine accumulation above the snow-line. If the snow-fall there exceed the amount that is thawed and evaporated, it must either go on growing upward until it reaches the highest cloud, or atmospheric region, from which it falls, or is formed, or it must descend somehow.

If ice can be squirted through a syringe by mere hand-pressure, we are justified in expecting that it would be forced down a hill slope, or through a gully, or across a plain, by the pressure of its own weight when the accumulation is great. Such is the case, and thus are glaciers formed.

They are, strictly speaking, rivers or torrents of ice; they flow as liquid water does, and down the same channels as would carry the liquid surface drainage of the hills, were rain to take the place of snow. Like rivers, they flow with varying speed, according to the slope; like rivers, their current is more rapid in the middle than the sides; like rivers, they exert their greatest tearing force when squeezed through narrow gullies; and, like rivers, they spread out into lakes when they come upon an open basin-like valley, with narrow outlet.

The *Justedalsbrae* of Norway is a great ice-lake of this character, covering a surface of about 500 square miles, and pouring down its ice-torrents on every side, wherever there is a notch or valley descending from the table-land it covers. The rate of flow of such downpouring glaciers varies from two or three inches to as many feet per day, and they present magnificent examples of the actual fluidity or viscosity of an apparently solid mass. This viscosity has been disputed, and attempts have been made to otherwise explain the motion of glaciers, but while it is possible that it may be assisted by varying expansion and contraction, the downflow due to viscosity is now recognized as unquestionably the main factor of glacier motion.

Cascades of ice may be sometimes seen. In the course of my first visit to Norway, I wandered alone over a very desolate mountain region toward the head of the Justedal, and unexpectedly came upon a gloomy lake, the Styggevand, which lies at the foot of a precipice-boundary of the great ice-field above-named. Here, the ice having no sloping valley trough by which to descend, poured over the edge of the precipice as a great overhanging sheet or cornice, which bent down as it was pushed forward, and presented on the convex side of the sheet some fine blue cracks, or "crevasses," as they are called. These gradually widened and deepened, until the overhanging mass broke off and fell into the lake, on the surface of which I saw the result, in the form of several floating icebergs that had previously fallen.

Something like this on a small scale may be seen at home on the edge of a house roof on which there has been an accumulation of snow; but, in this case, it is rather sliding than flowing that has made the cornice; but its *down-bending* is a result of viscosity.

PART III.

That the solid and liquid states of matter are not distinctly and broadly separable, but are connected by an intermediate condition of viscosity, which is more or less common to both, has, I think, been sufficiently shown in the previous papers, and the proofs of this are familiar enough.

We now come to the question whether there is any similar continuity between liquids and gases. Ordinary experience decidedly suggests a negative answer. We can point to nothing within easy reach that has the properties of liquid and gaseous half-and-half; that stands between gases and liquids as pitch and treacle stand between solids and liquids.

Some, perhaps, may suggest that cloud matter—London fog, for example—is such an intermediate state. This, however, is not the case. White country fog, ordinary clouds, or the so-called "steam" that is seen assuming cloud-forms as it issues from the spout of a tea-kettle or funnel of a locomotive, consist of minute particles of water suspended in air, as solid particles of dust are also suspended. It has been called "vesicular vapor," on the supposition that it consists of minute vesicles, like soap-bubbles on a very small scale, but this hypothesis remains unproven. London fog consists of similar particles, varnished with a delicate film of coal tar, and interspersed with particles of soot.

In order to clearly comprehend this question, we must define the difference between fluids and gases. In the first place, they are both fluids, as already agreed. What, then, is the essential difference between liquid fluidity and gaseous fluidity? The expert in molecular mathematics, discoursing to his kinematical brethren, would produce a tremendous reply to this question. He would describe the oscillations, gyrations, collisions, mean free paths, and mutual obstructions of atoms and molecules, and, by the aid of a maddening array of symbols, arrive at the conclusion that gases, unless restrained, are liable to indefinite or vast expansion, while liquids, of their own accord, retain definite limits or dimensions.

The matter-of-fact experimentalist demonstrates the same, by methods that are easily understood by anybody. I shall, therefore, both for my own sake and my reader's, describe some of the latter.

In the first place, we all see plainly that liquids have a surface, *i. e.*, a well-defined boundary, and also that gases, unless inclosed, have not. But as this may be due to the invisibility of the gas, we must question it further. The air we breathe may be taken as a type of gases, as water may of liquids. It has weight, as we may prove by weighing a bottle full of air, then pumping out the contents, weighing the empty bottle, and noting the difference.

Having weight, it presses toward the earth, and is squeezed by all that rests above it, and thus the air around us is constrained air. It is very compressible, and is accordingly compressed by the weight of all the air above it.

This being understood, let us take a bottle full of water and another full of air, and carry them both to the summit of Mont Blanc, or to a similar height in a balloon. We shall then have left nearly half of the atmosphere below, and thus both liquid and gas will be under little more than half of the ordinary pressure. What will happen if we uncork them both? The liquid will still display its definite surface, and remain in the bottle, but not so the gas. It will overflow upward, downward, or sideways, no matter how the bottle is held, and if we had tied an empty bladder over the neck before uncorking, we should find this overflow or expansion of the gas exactly proportionate to the removal of pressure, provided the temperature remained unaltered. Thus, at just half the pressure under which a pint bottle was corked, the air would measure exactly one quart, at one-eighth of the pressure one gallon, etc.

We cannot get high enough for the latter expansion, but can easily imitate the effect of further elevation by means of an air-pump. Thus, we may put one cubic inch of air into a bladder of 100 cubic inches capacity, then place this under the receiver of an air-pump, and reduce the pressure outside the bladder to one one-hundredth of its original force. With such atmospheric surrounding, the one cubic inch of air will plump out the flaccid bladder, and completely fill it. The pumpability of the air from the receiver shows that it goes on overflowing from it into the piston of the pump as fasts as it own elastic pressure on itself is diminished.

Numberless other experiments may be made, all proving that all gases are composed of matter which is not merely incohesive, but is energetically self-repulsive; so much so, that it can only be retained within any bounds whatever by means of some external pressure or constraint. For aught we know *experimentally* the gaseous contents of one of Mr. Glaisher's balloons would outstretch itself sufficiently to occupy the whole sphere of space that is spanned by the earth's orbit, provided that space were perfectly vacuous, and the balloon were burst in the midst of it, and the temperature of the expanding gas were maintained.

Here, then, in this self-repulsiveness, instead of self-cohesion, this absence of self-imposed boundary or dimensions, we have a very broad and well-marked distinction between gases and liquids, so broad that there seems no bridge that can possibly cross it. This was believed to be the case until recently. Such a bridge has, however, been built, and rendered visible, by the experimental researches of Dr. Andrews; but further explanation is required to render this generally intelligible.

Until quite lately it was customary to divide gases into two classes—"permanent gases" and "condensable gases" or "vapors." Gaseous water or steam was usually described as typical of the latter; oxygen, hydrogen, or nitrogen, of the former. Earlier than this, many other gases were included in the permanent list; but Faraday made a serious inroad upon this classification when he liquefied chlorine by cooling and compressing it. Long after this, the gaseous elements of water, and the chief constituents of air, oxygen, hydrogen, and nitrogen, resisted all efforts to condense them; but now they have succumbed to great pressure and extreme cooling.

We thus arrive at a very broad generalization, viz., that all gases are physically similar to steam (I mean, of course, "dry steam," *i. e.*, true invisible steam, and not the cloudy matter to which the name of steam is popularly given), that they are all formed by raising liquids above their boiling-point, just as steam is formed when we boil water and maintain the steam above the boiling-point of the water.

But some liquids boil at temperatures far below that at which others freeze; liquid chlorine boils at a temperature below that of freezing water, and liquid carbonic acid below even that of freezing mercury, and liquid hydrogen far lower still. These are cases of boiling, nevertheless, though it seems a paradox according to the ideas we commonly attach to this word. But such ideas are based on our common experience of the properties of our commonest of liquids, viz., water.

When water boils under the conditions of our ordinary experience, the passage from the liquid to the gaseous state is a sudden leap, with no intermediate state of existence that we are able to perceive; and the conditions upon which water is converted into steam—the liquid into the gas—while both are at the bottom of our atmospheric ocean, are such as to render an intermediate condition rationally, as well as practically, impossible.

We find that the expansive energy by which the steam is enabled to resist atmospheric pressure is conferred upon it by its taking into itself, and utilizing for its expansive efforts, a large amount of calorific energy. When any given quantity of water is converted into steam, under ordinary circumstances its bulk *suddenly* becomes above 1,700 times greater—a cubic inch of water forms about a cubic foot of steam, and nearly 1,000 degrees of heat (966·6) disappears *as temperature*. Otherwise stated, we must give to the cubic inch of water at 212° as much heat as would raise it to a temperature of 212 plus 966·6, or 1178·6° if it remained liquid. This is about the temperature of the glowing coals of a common fire; but the steam that has just taken enough heat to make the water red hot is still at 212°—no *hotter* than the water was while boiling.

This heat, which thus ceases to exhibit itself as *temperature*, is otherwise occupied. Its energy is partly devoted to the work of increasing the bulk of the water to the above-named extent, and partly in conferring on the steam its gaseous specialty—that is, in overcoming liquid cohesion, and substituting for it the opposite property of internal repulsive energy which is characteristic of gases. My reasons for thus defining and separating these two functions of the so-called "latent" heat will be seen in the next paper, when we come to the philosophy of the interesting researches of Dr. Andrews.

[*To be continued.*]

In a sample of urine which had been preserved for about one hundred years in a glass bottle, there was noticed, in addition to some microscopic particles of calcium carbonate and ammonium chloride, three large monoclinic crystals. These upon analysis proved to be ammonium magnesium phosphate. The urea was found to have been completely changed into ammonium carbonate.—*H. Schwanert, in Ber. Deut. Chem. Gesell.*, xv., 37. M. B.

SOME OF THE INDUSTRIAL USES OF THE CALCIUM COMPOUNDS.*

By THOMAS BOLAS, F.C.S.

Lecture III.—Delivered December 4, 1881.

SULPHATE OF LIME AND ITS OCCURRENCE IN NATURE. GYPSUM AND ALABASTER.—PLASTER OF PARIS, ITS PREPARATION AND USES.—PHYSICAL AND CHEMICAL ASPECTS OF THE SETTING OF PLASTER.—ACCELERATING AND RETARDING INFLUENCES.—SCIENTIFIC PRINCIPLES INVOLVED IN SOME OF THE APPLICATIONS OF PLASTER.—MOULDING, STEREOTYPING, AND OTHER PROCESSES.

THE sulphate of calcium, although it is neither so abundant nor so important from an industrial point of view as the carbonate, has properties which are perhaps more interesting and noteworthy in themselves.

Sulphate of calcium is perhaps as widely diffused as the carbonate, being present in almost all spring waters and soils, but we do not meet with compact masses of the sulphate which are at all comparable in magnitude with the larger deposits of calcium carbonate. In some instances, the sulphate and the carbonate occur together in the same mineral, as in the case of the so-called montmartrite, which is so abundantly found in the neighborhood of Paris.

Sulphate of calcium occurs in the anhydrous form, that is to say, without any water of crystallization, as the mineral anhydrite; but this occurs so sparely as to be of no industrial importance. When combined with two molecules of water of crystallization, it presents the various forms of gypsum or plaster stone; among which may be mentioned the earthy or almost amorphous varieties; the clear and nearly transparent forms, often known as alabaster; the fibrous kinds, and that which is crystallized in flattened prisms, and is known as selenite. A very complete collection of specimens of the various kinds of gypsum or sulphate of lime, as found in various parts of the world, are on the side table yonder; many of these having been kindly supplied by the Director of the *Societe des Plâtrières Reunées*, of Paris; Messrs. Bellman & Ivey, Messrs. Dennett & Ingle, and others.

In this country, the principal deposits of calcium sulphate which are useful industrially occur in Nottinghamshire, Leicestershire, and Derbyshire; but notable quantities occur in Cumberland, and smaller deposits in Sussex, Kent, and Somerset. Few countries are without tolerably large deposits of gypsum in one form or another, and Switzerland, the Tyrol, Sicily, the United States, and some of the South American districts being notable in this respect. Apart from these localities, the immediate neighborhood of Paris stands pre-eminent; but the gypsum found there usually contains over 10 per cent. of carbonate of calcium, not, as a rule, in intimate union with the sulphate, but interspersed in the form of grain. This carbonate gives the Paris plaster some of its most useful properties as a constructive material.

The flat crystalline prisms, like the amorphous masses of gypsum, contain $CaSO_4+2H_2O$, and if you reckon this out, it will correspond to nearly 2. per cent. of water. Sulphate of calcium is soluble in about 525 parts at the freezing point, and in 466 parts of water, at a temperature of 38° Centigrade. As the temperature is elevated above this point, the solubility of the sulphate of lime diminishes until at a heat of 150° Centigrade, it becomes almost insoluble. The presence of certain saline bodies notably increases the solubility of sulphate of calcium in water; sodium chloride, or common salt, to a moderate extent; while sodium hyposulphite increase the solubility of the gypsum about eightfold. This circumstance gives chemists a useful method for effecting the analytical separation of barium and calcium. The crystallization of gypsum from warm water, or from water containing a little hydrochloric acid, is a pretty experiment, and as the solution in this globe cools, you will see fine needle-shaped crystals of the hydrated sulphate shoot out, and form tufts nearly resembling the crystals of sulphate of quinine. These crystals make an admirable material for the loading of paper, as they possess a certain amount of strength or toughness themselves. Here is a sample of the hard and stony sulphate of calcium, which separates from water when it is evaporated in a steam boiler, and you know well how severe accidents frequently happen through the undue accumulation of such incrustations. In connection with this matter, you will not forget that at a temperature of 150° Centigrade, sulphate of calcium is nearly insoluble in water.

Sulphate of calcium is readily obtained in a state of purity by precipitation, when a soluble calcium salt is mixed with a sulphate in solution. Here is a moderately dilute solution of calcium chloride, to which will be added some sodium sulphate; and after a few minutes the deposition of the calcium sulphate will commence, the precipitate consisting of minute needles, similar to those obtained by deposition from warm water, but somewhat smaller. Sulphate of calcium fuses at a bright red heat, and on cooling assumes the crystalline state.

One of the most remarkable circumstances in connection with sulphate of lime is the fact that when the crystals are heated sufficiently to drive off two-thirds of their water, the residue possesses the property of rapidly setting or hardening when mixed with somewhat more water than that which was originally driven off. In this case it appears that chemical union with the added water takes place, and that the original body, $CaSO_4+2H_2O$ is reproduced.

Here is a glass retort which is partially filled with coarsely powdered gypsum, and you will see that when a gentle heat is applied by means of this gas burner, a large quantity of water will distill over. A heat of 120° Centigrade is sufficient to drive off about three-fourths of the water, and in preparing plaster it is necessary that the heat should not exceed 250° Centigrade, as good quick-setting plaster should retain five per cent. of water, and have a composition nearly corresponding with the formula:

$$2CaSO_4+H_2O.$$

It is interesting to note that the sulphate of lime ordinarily deposited in steam boilers possesses this same composition of two molecules of the anhydrous sulphate and one of water; and, moreover, this hydrate can be obtained by heating the ordinary gypsum with water to 150° in a sealed tube.

When plaster of Paris sets, or the partially dehydrated gypsum reunites with the water which was driven off in the baking, a perceptible amount of heat is produced, an elevation of temperature to the extent of 30° Centigrade being often observable. Here is a bell jar in which there is a flask which will serve as the bulb of an air thermometer, and now

* Four lectures delivered before the Society of Arts, London. Lecture I. in SUPPLEMENT, No. 327; Lecture II., SUPPLEMENT, No. 328.

that the bell-jar has just been filled with freshly-mixed plaster of Paris, you will soon observe evidence of heat in the movement of the column of colored liquid which is in the tube of the air thermometer. When plaster sets, an expansion of about one per cent. occurs, and this can be very well illustrated by filling a bottle with mixed plaster, corking it securely, and setting it on one side until it bursts from the internal pressure.

If the plaster has been burned at a higher temperature than that mentioned above, it will contain a greater or less proportion of anhydrous sulphate of calcium, and instead of setting rapidly when mixed to a thin cream with water, it will only become hard after a lapse of a considerable time, perhaps days or weeks; but in the end the ordinary hydrate $CaSO_4+2H_2O$ is formed. Some important applications of a gypsum calcined at a high temperature will be considered in a few minutes.

The residual water of plaster of Paris may be replaced by certain saline bodies, as, for example, alum, sulphate of potassium, or borax, these substances being generally added to the baked gypsum in the form of solution; after which it is subjected to a somewhat higher temperature than before—a temperature which would dead burn ordinary plaster. These cements (Keene's, Martin's, and Keating's) set in a few hours, and ultimately become so hard as to be capable of receiving a high polish.

The various kinds of stucco consist essentially of plaster, to which slaked lime may have been added, a solution of size being used for mixing; these additions causing the material to set sufficiently slowly to enable the mixture to be worked in the pasty or dough form. Marble-dust, sand, brick-dust, and other materials may be added to stucco in order to modify its character when necessary.

The applications of plaster in its various forms are numerous and important. First, as regards the use of a high calcined plaster as a constructive material. Messrs. Dennett & Ingle manufacture a large quantity of plaster, which is burned in an open furnace, like ordinary lime; and they apply this principally to the construction of fire-proof arches and floors; the plaster being made into concrete with fragments of brick or some similar aggregate. During the operation of calcination, a considerable, but somewhat variable, proportion of the sulphate of lime becomes decomposed, and the result is, that this high calcined plaster of Messrs. Dennett & Ingle contains a notable proportion of free lime and of oxysulphide of calcium. Its value as a material for fire-proof construction depends, in a great measure, on these circumstances, as otherwise the plaster cement would fuse in a fierce fire; whereas experiment has proved that, in ordinary cases, the calcareous cement resists the action of fire even more perfectly than the brick aggregate. And, moreover, the concrete which has been exposed to fire has not so great a tendency to crumble under the subsequent influence of damp as is the case with ordinary Portland cement concrete, under similar circumstances. Numerous specimens, illustrative of Messrs. Dennett & Ingle's system of using their concrete for various fire-proofing purposes, are before you, and diagrams representing sections of floors and arches are fastened to the wall yonder. The concrete takes three or four days to set sufficiently for the removal of the centerings, and in the case of arches of six or seven feet span, a thickness of four inches is considered sufficient.

Another point in connection with this high calcined plaster as a fire-proofing material. Here are samples of wood and iron encased with it, the casing being in some cases but little over an inch thick; but these casings are found to protect wood or iron against the action of flame for a considerable time, and will probably prove of great value in the treatment of old buildings such as theaters.

The use of a selenitic or gypsum mortar is of advantage in many cases, the usual thing being a mixture of well-burned gypsum and lime; samples which are known to have been used over 350 years ago being now in excellent condition, and harder than the stones which are cemented. In Paris, various kinds of gypsum mortars are in general use, raw gypsum and other inert materials being often intermixed. It will be remembered that the plaster used in Paris contains free lime or carbonate of lime according to the degree of heat to which the raw stone has been subjected. The Hotel de Platres in Paris affords good illustrations of the constructive uses to which plaster can be put, some of the blocks being over eighty years old.

Plaster of Paris makes admirable drying tiles for laboratory or manufacturing use; its porous structure rapidly removing and carrying away moisture from any wet and insoluble powder.

An illustration of the fineness of detail which can be moulded by plaster of Paris is well illustrated by these specimens of photo-engraving work executed by Mr. Dallas; plaster having been used in casting from the original phototypic model, after which the actual printing block is cast in the plaster-mould. The perfection with which plaster can mould fine details depends, to a considerable extent, on the circumstance that expansion takes place just as the plaster sets.

The operation of stereotyping affords a good illustration of an important use of plaster of Paris. Here is a form of type, the surface of which is slightly oiled. A border being placed round the edges of the form, you see that liquid plaster is poured on, the production of air bubbles on the surface of the type being prevented by dabbing through the liquid plaster with a camel's-hair brush. In a few minutes it will be sufficiently set for removal from the type, but in order to expedite matters, a similar cast was prepared before the lecture; and it is now dry and hot in yonder gas oven. The hot cast is now placed face downward in this flat metal pan, which is also hot; and after it has been properly secured, melted type metal is allowed to flow between it and the bottom of the pan. Sufficient has now been run in to thoroughly cover the cast, and this gas burner will keep it melted until the end of the lecture, after which it will be allowed to cool, when a cast, free from air bubbles or defects, is likely to be obtained.

Buns and tarts built up out of plaster and textile materials, and ingeniously painted to represent the real articles, form better materials for Christmas trees than for the usually accompanying feeds; and Mr. Barker will hand round a plate of them for your inspection. This kind of fraud on the unsuspecting lovers of confectionery has often one redeeming feature, as the imitation tart opens at the bottom, and reveals a store of sweetmeats. Those which Mr. Barker is handing round are, however, grosser frauds, as on opening the door at the bottom you will merely find a sarcastic inquiry as to your capability of eating a tart. Similar things built up of plaster and canvas are largely used as theatrical properties, and may represent rocks, animals, or other objects.

Messrs. Bellman & Ivey tell me that their extra superfine plaster, of which they have sent me some samples, is not only used in making the Scagliola for which they are so celebrated, but that many tons are sold each year to makers of sugar-almonds and other delicacies for children. You see, then, that plaster is used in fabricating the real as well as the imitation confectionery.

As regards the imitation marble or Scagliola, which is so successfully manufactured by Messrs. Bellman & Ivey, you have only to look around to see some very fine specimens. This you may regard as Keene's cement, which has been colored by suitable pigments; the various dough-like colored plasters being incorporated so as to obtain the artistic and admirable results which you see before you. When thoroughly set, the articles are trued to shape and polished. Messrs. Bellman & Ivey tell me that in no case is the natural face of the cement hardened or prepared in any way, it being merely worked true and polished.

Something of a similar character can be made by mixing plaster to a pasty consistency, with a dilute solution of size, the required pigments being added. When the differently-colored plasters have been incorporated, and the articles have become hard, the material is soaked with linseed oil, and polished with turpentine and wax. Fine plaster is often used for making crayons, which are to be used instead of chalk in writing on the black board, and Messrs. Lewis Wolff & Sons have lent me these specimens of plaster crayons, which they manufacture largely.

Plaster moulds are almost exclusively used for moulding the various articles of earthenware, and here is a mould with damp clay jug still in it; this having been kindly sent here by Mr. Emery, of Burslem.

Among other uses of plaster may be mentioned its use to separate the carbons in the Jablochkoff electric candle, for mounting various articles in sockets or on spindles, and for insuring a steady bearing between surfaces of metal and wood as in the case of the iron plates which are bolted down to the woodwork of pianofortes for holding the pins.

The mineral tripolite, which consists principally of silica, lime, and protoxide of iron, yields a quick-setting cement when slightly calcined, and may be used instead of plaster in many cases.

IMPROVED PROCESSES FOR THE DETECTION OF ALUM IN FLOUR AND BREAD.*

By A. WYNTER BLYTH, M.R.C.S., ETC.

DETECTION OF ALUM.—Neither the mere detection of alum in flour, nor as for that its estimation, presents any difficulty, for we have by the chloroform process a method of separating nearly all the alum added as alum; therefore the remarks I am about to make apply chiefly to bread, although flour was used in many of the experiments as more convenient. The logwood test, as usually applied to bread or flour, I have found wanting both in delicacy and sharpness, and this is especially the case when only small quantities of alum are present. Whether the colored bread is dried or undried, it often happens that of two equally good observers the one calls a sample, thus colored, dirtyish pink, the other bluish pink. Knowing the power that gelatine undoubtedly possesses of uniting with alum, I have attempted to utilize this property. A preliminary experiment was made with gelatine and pure solutions of alum. A few slips of gelatine were digested in a solution of alum of 1·10 per cent. strength for 12 hours, and the strength of the solution then ascertained. Alum withdrawn by the gelatine amounted to 15·8 per cent. A second experiment was made with a stronger solution, 2 per cent. In 15 hours the amount of alum which had been withdrawn by the gelatine amounted to 16·9 per cent. It therefore may be anticipated that gelatine will withdraw, and as it were concentrate a considerable percentage of alum from a solution.

The next experiments were made in the staining of gelatine slips by means of ammoniacal solution of logwood, that is fresh tincture of logwood, to which an equal bulk of 10 per cent. solution of carbonate of ammonia had been added. Gelatine soaked in distilled water, in pure cold aqueous extract of flour, or aqueous extract of pure bread, becomes of a reddish brown color without a trace of blue (see lithograph No 1). Such a slip put into glycerine decolorizes in a few hours, and then has a dirty yellow hue. Gelatine soaked in alum solutions, in watery extracts of alumed bread or flour, becomes of a blue tint, the shades varying from lavender blue up to cobalt (see lithograph No 2, gelatine dyed with logwood, alum, 1 : 10,000; No 3, 1 : 7,000; No 4, 1 : 1,000). More than this, the slips put into glycerine can be kept without changing color; how long the color thus remains I do not know, but I have some gelatine slips which are more than a month old, and they still retain their primitive freshness. The blue tint is very distinctly seen in solutions containing one part of alum in 10,000 parts of solution, and is still demonstrable in one part in 50,000, especially if the slip is placed in glycerine and its behavior noted. It therefore will detect one part of alum in one million parts of a solution, for such a dilute solution may be concentrated down to a smaller bulk. The application of the test is so simple that it scarcely needs description. Any convenient quantity of the bread is crumbled, put into a suitable glass vessel, and one or two little slips of dry commercial gelatine, proved to be pure by a blank experiment with distilled water, are placed with the bread, sufficient distilled water is added to well cover the mixture, and the whole is left over night. In the morning the bits of swollen gelatine are taken out and dyed with the alkaline logwood in the usual way. From some experiments it would appear that four minutes' immersion is the best time, for where the proportion of alum is very minute the alumed layer appears to be only on the surface, and the dye with longer periods sinking toward the unalumed core, colors the center reddish pink, and this pink center, shining through the blue cortex, confuses the color. But this statement must not be considered final, for there may possibly be some difference as to the kind of alum, whether ammonia or potash, and also as to the strength of the logwood tincture, which future experiments will determine. Having thus obtained a method of concentrating the alum on a little strip of an almost colorless jelly, a jelly that could be colored with the greatest ease by almost every dye, it was only natural to go further, and to see if the alumed jellies behaved differently to the unalumed jellies. Accordingly trials were made, very generally with the aniline colors; this quite in an empirical way, for there was no theoretical likelihood of success, and as a fact, but little difference was observed.

Attention was next turned to such tinctorial agents as madder, turmeric, litmus, brazil wood, chrysophanic acid, gamboge, garancine, and many others. Of these, madder, Brazil wood, garancine, and chrysophanic acid, when the solution was made ammoniacal, all tinted the gelatine a most decidedly different hue when pure than when alumed, but the logwood was chief, both in delicacy of reaction and depth of color, so that so far as we have gone there is nothing to equal logwood as an alum test. As for magnesia giving the same color, it is only the soluble salts of magnesia which do this. The magnesian phosphate in bread certainly does not color logwood, and the process to be given further on effectually distinguishes magnesia from alum.

Excessively small quantities of alum may be detected by obtaining the phosphate of alumina in the manner to be shortly described; fusing it with sulphate of soda on a platinum dish by a blowpipe, lixiviating the phosphate of soda produced, dissolving the residue with a very little dilute sulphuric acid, neutralizing with ammonia. Then in this liquid, which need not be more than a cubic centimeter, steep a small bit of gelatine, and when the gelatine is sufficiently swollen and softened, it is colored with logwood as before, and will show the reaction.

CAN ALUM BE EXTRACTED OUT OF BREAD OR FLOUR BY WATER?—It has been generally asserted that when alum is added in powder or solution to flour, and that flour is kneaded up with water or made into bread, the alum ceases to exist as alum, but forms phosphate of alumina. That phosphate of alumina is the form in which alum appears in the ash, I freely admit; that phosphate of alumina is formed say in minute quantity in the bread itself I by no means admit, and consider it quite an open question. Take an aqueous extract of flour, filter it by the aid of a pressure pump, and add a little solution of alum, there is no precipitate; add a little phosphate of soda or potash, and a cloud is immediately perceived. Although phosphate of potash is found in the ash obtained by evaporating down to dryness, and incinerating the aqueous extract, the behavior with solution of alum would render one doubtful of the existence of an alkaline phosphate in the watery extract were there not a simple explanation. The simple explanation is this, that phosphate of alumina is not fully thrown down from its solutions by an alkaline phosphate, except by an excess of that phosphate, so that it all depends as to the quantity of alum added, whether it is likely all to be in the state of phosphate or not. Again, if the alum is all converted into phosphate of alumina, it could hardly be washed out of bread or flour by water; but I have made some experiments which show that, by using relatively enormous masses of water, no inconsiderable quantity of alum is thus separated. But were such experiments needful?—the whole gelatine process is an ample proof of the possibility of extracting the alum from flour or bread by water, it cannot be considered possible for the gelatine to have attracted and united with such an insoluble substance as phosphate of alumina—it must be united to a soluble salt of alumina, in short, to alum itself.

EXPERIMENT.—20 parts of alum, 3,500 parts of flour, and 28,000 parts of water were mixed together, and the whole set aside for 72 hours. The flour as usual settled to the bottom, leaving a clear supernatant fluid. A fractional portion of this clear fluid was decanted, a little sodic phosphate added, and the liquid boiled slowly down to dryness in a platinum dish incinerated and the phosphate of alumina separated and determined in the way familiar to all chemists. The amount of alumina phosphate calculated on the whole as alum was 2·55 parts or 12·7 per cent. of the alum originally added. Hence in this experiment, in which the proportion of water to alum was as 1,400 is to 1, over 12 per cent. of the original alum was recovered.

EXPERIMENT.—Three loaves, A, B, and C, were made with a flour which was proved to be pure. Definite quantities of alum were added to two of the loaves, the third was made of the pure flour. A, 5 parts alum, 8,438 parts of flour; B, 5 parts alum, 3,503 parts of flour; C, flour, 7,545 parts. In the A loaf the alum was added to the flour in powder and mixed dry with the flour. In B loaf the alum was added in solution. The loaves were fermented and baked in the usual way. Then the three loaves were cut into small pieces and soaked in three separate jars, each jar containing 49,000 parts of distilled water. After three and a half days' soaking the liquid was separated by filtration, and the residue on the filter weighed, and the necessary calculations made, so that the amount of water still adhering to the bread was known, and could be allowed for. The three filtrates were respectively evaporated to dryness after the addition of a little sodic phosphate, and the three extracts dried and incinerated, and the three ashes treated in the usual manner so as to obtain as a final result, any alumina phosphate, if present. The alumina phosphate calculated on the whole as alum separated was as follows: A yielded 1·493 parts of alum, B yielded 1·454 parts of alum, C yielded no trace. In this case then in which the water was 9,800 times the alum, the amount recovered by simple extraction with cold water was about 29 per cent.

QUANTITATIVE ESTIMATION OF ALUM.—If then by using large bulks of water it was possible to extract a portion of the alum, it was thought highly probable that by using a more powerful solvent, and especially one in which any aluminic phosphate would be dissolved, most if not all of the alum would be dissolved. It was also a question whether by this means there could not be devised a method to distinguish between alumina added as alum and alumina present as silicate of alumina. Kaolins, composed of silicates of alumina with other silicates, were taken and digested in 5 per cent. hydrochloric acid in the cold, but no alumina was found in the solution. Even a 35 per cent. hydrochloric acid, acting for 24 hours in the cold, failed to decompose the silicate of alumina. On the other hand, London clay was acted on by 5 per cent. hydrochloric acid, and parted with much iron and a minute quantity of phosphate of alumina. This is possibly derived not from a decomposition of a silicate, but a mere solution of a pre-existing phosphate of alumina.

EXPERIMENTS WITH BREAD.—Five commercial loaves of bread from various sources, none of which gave any reaction with the logwood test, whether applied in the old or in the new way, were severally crumbled and digested with a large quantity of 5 per cent. hydrochloric acid. The acid liquid was poured off the bread, a little sodic phosphate added, and then the acid was neutralized with ammonia, and the liquids boiled down to dryness in a platinum dish, the extract incinerated, etc., etc., but none of the five yielded to the ordinary analytical methods the least trace of phosphate of alumina.

EXPERIMENT.—A sample of pure flour was taken and divided into three parts. The three flours were then mixed as follows: No. 1, alum 10, flour 1,750 parts; No. 2, alum 10, kaolin 10, flour 1,750 parts; No. 3, kaolin 10, magnesia

* Read before the Society of Public Analysts, January 18, 1882.

10. flour 1,750 parts. The flour thus prepared was made up into three loaves. The three loaves were finally each treated in the cold with 12,250 parts of 5 per cent. hydrochloric acid acting for 24 hours. Two thirds of the whole quantity was decanted off, one third remained with the bread. From No. 1, 95·8 per cent. of the alum added was recovered as phosphate of alumina. From No. 2, 99 per cent., that is of course calculated on the whole. The difference between the two determinations was considered to be due to loss, considerable spluttering occurring toward the end of the operation. No. 3, though containing silicate of alumina added in the form of kaolin, yielded no alumina phosphate. Other experiments have been made and are still proceeding, and so far they tend to substantiate the hydrochloric process as superior to the old burning up methods in which a correction has to be made for the silica. Although, thanks to the researches of Dr. Dupré, followed by those of Mr. Carter Bell, the proportion of silica to alumina must be considered as well established as the nature of the thing permits, yet this correction no one can call perfectly satisfactory.

It may be expected that I should mention a recent case in which a difference of opinion between myself and the Somerset House laboratory appears to have arisen. A sample of bread which gave both by the old fashioned method of applying logwood a pronounced blue, and also by the gelatine method an almost cobalt blue, and finally from which sufficient alum was extracted by water, out of 250 grains, to color blue the gelatine slip No. 5, and in which I found, after allowing 12 grains of alum for 12 grains of silica (for I had not worked at that time sufficiently the hydrochloric acid process), I returned as containing nearly 19 grains of alum to the 4 lb. loaf. Now, 19 grains is not much, but it is most decidedly a quantity that, having done so much work in the subject, I was not likely to make a mistake as to *the presence* of alum. However, the Somerset House chemists could find no alum in their sample, and gave a laconic certificate, "Free from alum." Although I may have my own ideas on the subject, I cannot swear that their sample contained alum, for there is always the possibility of unequal admixture. But what I can legitimately criticise is, the form of their certificate. There are similar referees in both France and Germany, yet in all cases the referees draw up a report stating in full all operations and experiments they have performed, and the reasons for their conclusions. It would be considered most discourteous and unprofessional in those countries, to give simply an opinion without details. If the Somerset House chemists are to take advantage of the accident of official position as referees, and to act in this way, it will be absolutely essential for the Public Analysts to take united action in a representation to the Government and press for some very decided modification of the present Sale of Food and Drugs Act.

Returning from this digression, which is scarcely germane, I must in conclusion point out clearly that I by no means pretend to have settled the hydrochloric acid process. This paper is only a preliminary note. I do not advise any one to rely upon the process until many more determinations have been made; and one of the main objects of publishing the process so early is in the hope that some of my *confreres* will take it up and for the next few months analyze all breads both by the old and the new methods and publish the results. I have to thank my assistant, Mr. Grinwood, for his very valuable and active co-operation in performing the experiments on which this paper is based.

NOTES OF SOME EXPERIMENTS ON THE ACTION OF ORGANIC MATTER ON SILVER SALTS.*

By HENRY LEFFMANN, M.D., Microscopist to the Pennsylvania State Board of Agriculture.

THE action of organic matter upon silver salts is well known, but I am not aware of any attempts to utilize this method for the examination of water. The following experiments were undertaken as a sort of preliminary investigation. The subject of water analysis is so important, and so much remains to be done, that every observation of the kind must have some value.

If we add a salt of silver to ordinary water, the precipitated chloride interferes with the test, and to prevent this, I used a solution containing marked excess of ammonia. In the following experiments, the proportion used was 2 c. c. of ammonio-nitrate of silver to 100 c. c. of the water. The silver solution contained only a few grains to the ounce. When not otherwise mentioned, the water was exposed to the sunlight for two hours.

1.	Distilled water	No color.
2.	Schuylkill "	"
3.	Ditto " with 0·1 c. c. urine	Brown color.
4.	Ditto " with 0·5 c. c. urine	Deep brown.
5.	Ditto " with 0·02 c. c. urine.	Red brown.
6.	Ditto " with 4 grs. raw sugar	No color.
7.	Ditto " with 2 grs. stale mash	Yellowish.
8.	Well water, not perfectly pure, but not unfit to drink	Faint black.
9.	Ditto " markedly contaminated	Black precipitate almost immediately.
10.	Water from a small stream, quite pure.	No color.

Waters containing small amounts of milk, glucose, and albumen gave no distinct effects. Solution of glue produced a faint brown. All the experiments tended to show that the test was very sensitive to the presence of urine. Some experiments were made with highly dilute solutions of the common active principles.

Quinidia, strychnia, and cinchonidia gave no result. Picrotoxin gave light yellow. Caffeine gave light yellow. Quinidine sulphate gave faint brown. Morphia gave immediate precipitate.

I hope to present before long the results of some further study of the matter.—*The Analyst.*

MEASUREMENT OF POTENTIALS CORRESPONDING TO GIVEN EXPLOSIVE DISTANCES.

By J. B. BAILLE.

THE potential of an electrized plane increases about regularly with the explosive distance to be traversed. The electric densities may be calculated corresponding to these different spark lengths; it will be seen that these densities decrease at first slowly, and soon arrive at a constant value, about 0·5 cm. The pressure exerted by electricity upon the air at the moment when the spark is about to spring 0·01 meter is only one two thousandth of the atmospheric pressure.

* Read before the Society of Public Analysts, February 15, 1882.

THE GENESIS AND DISTRIBUTION OF GOLD.

By PROF J. S. NEWBERRY.

MOST of the quartz veins which carry gold belong to the class of what are called segregated veins. These occur only in metamorphic rocks, are lenticular sheets, limited in depth and lateral extension, and generally showing little of the banded structure so characteristic of fissure veins. They consist mainly of quartz, in which the gold is sometimes free, but more commonly contained in iron pyrites, with which yellow copper is often associated. Sometimes the gold is not strictly confined to the quartz veins but extends more or less into the inclosing rocks, which are oftener than otherwise magnesian slates.

The gold in segregated veins would seem to be indigenous to the formation in which it occurs, and not, as in fissure-veins, to have been derived from some foreign source. It is usually supposed that, before they were metamorphosed, the rocks which inclose the segregated veins, contained gold generally, though sparsely disseminated through them, and that, in the process of the segregation of the silicious matter to form sheets of quartz, the gold was somehow gathered and concentrated by it.

Sir Roderick Murchison, guided by his study of the gold deposits of the Ural Mountains, supposed that auriferous quartz veins were confined to Paleozoic rocks, but that the gold impregnation had taken place at a comparatively recent date. It was demonstrated, however, by Professor Whitney, in the prosecution of the geological survey of California, that the metamorphic slates which carry gold in the Sierra Nevada are of Triassic and Jurassic age; and in the light of later observations, we may say that metamorphic rocks of all ages contain auriferous veins. Nearly all the great mountain chains of the world contain more or less of such veins, and as these mountain chains have been the great condensers of moisture, and erosion has been constantly wearing down their slopes, placer deposits have been formed which have supplied most of the gold yielded by the earth to man. As it can be procured from them by the simplest methods, the work of its extraction was begun by prehistoric races, and the Altai, the Himalayas, the Ural Mountains, the Australian Alps, the Sierra Nevada, and the Rocky Mountains, have in turn contributed their millions to the treasuries of the world. These mountain chains are of very different ages, and we have abundant evidence that gold has existed in some of them from the earliest geological times. The oldest mountains of which we have any knowledge—the Laurentian, of Canada, now nearly removed by erosion—contained auriferous quartz veins that have supplied gold to all the successive formations which have been derived from their ruins. The gold impregnation of the Laurentian rocks date back certainly to the period of their metamorphism; and this was pre-Silurian, for the undisturbed lower Silurian strata overlap and partially cover these gold-bearing rocks.

In the same way, the gold at the Black Hills is proved to be pre-Silurian, since the Potsdam sandstone which abuts against the Archean nucleus of the hills in places contains rolled fragments of the Archean rocks, and gold washed from them in such abundance as to form rich mining ground—the so-called cement deposits of that region. The distribution of gold from the Archean rocks has probably been constantly going on from the Silurian age to the present day. This is shown in the almost universal dissemination of gold through the drift of New England, New York, Ohio, etc., where the superficial materials have been largely derived from the Canadian highlands. In Ohio, gold is found in the drift clays, sands, and gravels, and locally in as great quantity as in the poorer placers of California. There is little doubt that the mechanical sediments derived from the wear of the Archean rocks all contain gold, and since it has been proved that gold exists in sea-water, it has probably impregnated all the organic marine sedimentary rocks as well. In the subsequent metamorphism of some of these strata it has been concentrated in such a way as to produce auriferous quartz veins rich enough to be worked.

From these facts it will be seen that there is no geological age which can be called the age of gold. It existed in the oldest rocks known, and from them and their derivatives, more modern rocks, it has been, and is now, being constantly distributed by both mechanical and chemical processes. Even some of the igneous rocks of the western country are said to contain minute quantities of gold;* and this is not surprising, if, as is supposed, much of our volcanic material is a fused condition of sedimentary rocks.

GOLD IN FISSURE-VEINS.

As is well known, gold is a frequent constituent of the fissure-veins of the Far West. The ore of the Comstock vein has yielded about forty-seven per cent. of gold and fifty-three per cent. of silver; and it is probable that one-half of the so-called silver veins contain gold in sufficient quantity to be of practical value. In some true fissure-veins, gold is the only valuable ingredient, but more generally it is associated with several other metals. The Revenue Mine, at Tuscarora, Nev., contains silver in the form of arsenical and antimonial sulphide, and gold in iron pyrites frequently crystallized lining cavities. At Eureka, the ore occurs in chambers, which were originally filled from a solution issuing through fissures from below and deposited as argentiferous galena and auriferous pyrites, the silver and gold being in nearly equal proportions. In the great veins of Bingham Cañon, and at the Cave Mine, near Frisco in Utah, the combination is the same, and, as at Eureka, the sulphides have been decomposed to a spongy, rusty gossan. At the Bassick Mine, in Colorado, gold exists free, or in combination with tellurium, and associated with zinc, copper, and iron. In all these, and many other cases which might be cited, the gold has been brought up in a hot solution impregnated with mineral matter far below, and deposited as the temperature and pressure were reduced. The formation of this class of auriferous deposit is well illustrated by the Steamboat Spring, in Western Nevada, where hot water, flowing out through fissures produced by subterranean forces, is depositing a silicious vein-stone, containing sulphides of iron, copper, oxide of manganese, and metallic gold. There is little doubt that, in the great mineral belt lying between the Sierra Nevada and the Rocky Mountains, where, in Tertiary times, volcanic activity was exhibited on a grand scale—sedimentary rocks upheaved and fissured in every direction, with great outflows of fused material—hot springs, like the Steamboat, were everywhere busy, doing similar work. Bursting out at different places and times, and flowing from different sources, the solutions they carried and the ores they deposited varied greatly; but the methods of accumulation, transportation, and deposition were essentially the same, namely, the leaching of various rocks by steam and hot water under great pressure, by which silica and sparsely-disseminated metals were gathered and driven toward the surface, to be deposited as the pressure and temperature were reduced. Gold collected in this manner was unquestionably taken into chemical solution, and in the resulting vein deposits we find it in strings, scales, and irregular masses, often beautifully crystallized and associated with other crystallized minerals which are certainly chemical precipitates.

We may sum up the teachings of geology in regard to the genesis and distribution of gold by saying:

First. Gold exists in the oldest known rocks, and has been thence distributed through all strata derived from them.

Second. In the metamorphosis of these derived rocks it has been concentrated into segregated quartz veins by some process not yet understood.

Third. It is a constituent of fissure-veins of all geological ages, where it has been deposited from hot chemical solutions which have leached deeply-buried rocks of various kinds, gathering from them gold with other metallic minerals.

Fourth. By the erosion of strata containing auriferous veins, segregated or fissure, gold has been accumulated by mechanical agents in placer deposits, economically the most important of all the sources of gold.—*Engineering and Mining Journal.*

* For example, the basalt of the Snake River lava plain, and according to Prof. J. J. Stevenson, the trachyte of Colorado.

ON THE CONSERVATION OF SOLAR ENERGY.*

THE question of the maintenance of solar energy is one that has been looked upon with deep interest by astronomers and physicists from the time of La Place downward.

The amount of heat radiated from the sun has been approximately computed by the aid of the pyrheliometer of Pouillet and by the actinometers of Herschel and others at 18,000,000 of heat units from every square foot of its surface per hour, or, put properly, as equal to the heat that would be produced by the perfect combustion every thirty-six hours of a mass of coal of specific gravity =1·5 as great as that of our earth.

If the sun were surrounded by a solid sphere of a radius equal to the mean distance of the sun from the earth (95,000,000 of miles), the whole of this prodigious amount of heat would be intercepted; but considering that the earth's apparent diameter, as seen from the sun, is only seventeen seconds, the earth can intercept only the 2,250-millionth part. Assuming that the other planetary bodies swell the amount of intercepted heat by ten times this amount, there remains the important fact that [illegible] of the solar energy is radiated into space, and apparently lost to the solar system, and only [illegible] utilized.

Notwithstanding this enormous loss of heat, solar temperature has not diminished sensibly for centuries, if we neglect the periodic changes apparently connected with the appearance of sun-spots that have been observed by Lockyer and others, and the question forces itself upon us how this great loss can be sustained without producing an observable diminution of solar temperature even within a human lifetime.

Among the ingenious hypothesis intending to account for a continuance of solar heat is that of shrinkage, or gradual reduction of the sun's volume suggested by Helmholtz. It may, however, be urged against this theory that the heat so produced would be liberated throughout its mass, and would have to be brought to the surface by conduction, aided perhaps by convection; but we know of no material of sufficient conductivity to transmit anything approaching the amount of heat lost by radiation.

Chemical action between the constituent parts of the sun has also been suggested; but here again we are met by the difficulty that the production of such combination would ere this have accumulated on the surface, and would have formed a barrier against further action.

These difficulties have led Sir Wm. Thomson, following up Mayer's speculation, to the suggestion that the cause of the maintenance of solar temperature might be found in the circumstance of meteorolites falling upon the sun from great distances in space, or with an acquired velocity due to such fall, and he shows that each pound of matter so imported would represent a large number of heat units depending upon the original distance. Yet the aggregate of material that would thus have to be incorporated with the sun would tend to disturb the planetary equilibrium, and must ere this have shortened our year to an extent exceeding that resulting from astronomical records and observation. In fact, Sir William Thomson soon abandoned the meteoric hypothesis for that of simple transfer of heat from the interior of a liquid sun to the surface by means of convection currents, which latter hypothesis appears at the present time to be supported by Prof. Stokes and other leading physicists of the day.

But if either of these hypotheses could be proved, we should only have the satisfaction of knowing that the solar waste of energy by dissipation into space was not dependent entirely upon loss of its sensible heat, but that its existence as a luminary would be prolonged by calling into requisition a limited, though may be large, store of energy in the form of separated matter. The true solution of the problem will be furnished by a theory, according to which the radiant energy which is now supposed to be dissipated into space and irrecoverably lost to our solar system, could be arrested and brought back in another form to the sun itself, there to continue the work of solar radiation.

Some years ago it occurred to me that such a solution of the solar problem might not lie beyond the bounds of possibility, and although I cannot claim intimate acquaintance with the intricacies of solar physics, I have watched its progress, and have engaged also in some physical experiments bearing upon the question, all of which have served to strengthen my confidence, and ripened in me the determination to submit my views, not without some, misgiving to the touchstone of scientific criticism.

For the purposes of my theory, stellar space is supposed to be filled with highly rarefied gaseous bodies, including hydrogen, oxygen, nitrogen, carbon, and their compounds, besides solid materials in the form of dust. This being the case, each planetary body would attract to itself an atmosphere depending for its density upon its relative attractive importance, and it would not seem unreasonable to suppose that the heavier and less diffusible gases would form the staple of these atmospheres; that, in fact, they would consist mostly of nitrogen, oxygen, and carbonic anhydride, while hydrogen and its compounds would predominate in space.

But the planetary system, as a whole, would exercise an attractive influence upon the gaseous matter diffused through

* Paper read at the Royal Society, March 2, by C. William Siemens, D.C.L., LL.D., F.R.S., Mem. Inst. C. E.

space, and would therefore be surrounded by an interplanetary atmosphere, holding an intermediate position between the planetary atmospheres and the extremely rarefied stellar space.

In support of this view it may be urged that, in following out the molecular theory of gases as laid down by Clerk Maxwell, Clausius, and Thomson, it would be difficult to assign a limit to a gaseous atmosphere in space, and, further, that some writers, among whom I will here mention only Grove, Humboldt, Zoellner, and Mattieu Williams, have boldly asserted the existence of a space filled with matter, and that Newton himself, as Dr. Sterry Hunt tells us in an interesting paper which has only just reached me, has expressed views in favor of such an assumption. Further than this, we have the facts that meteorolites whose flight through stellar, or at all events through interplanetary space, is suddenly arrested by being brought into collision with our earth, are known to contain as much as six times their own volume of gases taken at atmospheric pressure; and Dr. Flight has only very recently communicated to the Royal Society the analysis of the occluded gases of one of these meteorolites taken immediately after the descent to be as follows:

CO_2	0·12
CO	31·88
H	45·79
CH_4	4·55
N	17·66
	100·00

It appears surprising that there was no aqueous vapor, considering there was much hydrogen and oxygen in combination with carbon, but perhaps the vapor escaped observation, or was expelled to a greater extent than the other gases by external heat, when the meteorolite passed through our atmosphere. Opinions concur that the gases found occluded in meteorolites cannot be supposed to have entered into their composition during the very short period of traversing our atmosphere, but if any doubt should exist on this head, it ought to be set at rest by the fact that the gas principally occluded is hydrogen, which is not contained in our atmosphere in any appreciable quantity.

Further proof of the fact that stellar space is filled with gaseous matter is furnished by spectrum analysis, and it appears from recent investigation by Dr. Huggins and others, that the nucleus of a comet contains very much the same gases found occluded in meteorolites, including "carbon, hydrogen, nitrogen, and probably oxygen," while according to the views set forth by Dewar and Liveing, it also contains nitrogenous compounds such as cyanogen.

Adversely to the assumption that interplanetary space is filled with gases, it is urged that the presence of ordinary matter would cause sensible retardation of planetary motion, such as must have made itself felt before this; but assuming that the matter filling space is an almost perfect fluid, not limited by border surfaces, it can be shown, on purely mechanical grounds, that the retardation by friction through such an attenuated medium would be very slight indeed, even at planetary velocities.

But it may be contended that, if the views here advocated regarding the distribution of gases were true, the sun should draw to itself the bulk of the least diffusible, and therefore the heaviest gases, such as carbonic anhydride, carbonic oxide, oxygen, and nitrogen, whereas spectrum analysis has proved on the contrary a prevalence of hydrogen.

In explanation of this seeming anomaly it can be shown, in the first place, that the temperature of the sun is so high, that such compound gases as carbonic anhydride and carbonic oxide could not exist within it, their point of dissociation being very much below the solar temperature; it has been contended, indeed, by Mr. Lockyer, that none of the metalloids have any existence at these temperatures, although as regards oxygen, Dr. Draper asserts its existence in the solar photosphere; there must be regions, however, outside that thermal limit, where their existence would not be jeopardized by heat, and here great accumulation of these comparatively heavy gases that constitute our atmosphere would probably take place, were it not for certain counterbalancing action.

I here approach a point of considerable importance in my argument, upon the proof of which my further conclusions must depend.

The sun completes one revolution on its axis in twenty-five days, and its diameter being taken at 882,000 miles, it follows that the tangential velocity amounts to 1·23 miles per second, or to 4·41 times the tangential velocity of our earth. This high rotative velocity of the sun must cause an equatorial rise of the solar atmosphere, to which Mairan, in 1741, attributed the appearance of zodiacal light. La Place rejected this explanation on the ground that the zodiacal light extended to a distance from the sun exceeding our own distance, whereas the equatorial rise of the solar atmosphere due to its rotation could not exceed 9-20ths of the distance of Mercury. But it must be remembered that La Place based his calculation upon the hypothesis of an empty stellar space (filled only with an imaginary ether), and that the result of solar rotation would be widely different, if it was supposed to take place within a medium of unbounded extension. In this case pressures would be balanced all round, and the sun would act mechanically upon the floating matter surrounding it in the manner of a fan, drawing it toward itself upon the solar surfaces, and projecting it outward in a continuous disk-like steam.

By this fan action, hydrogen, hydrocarbons, and oxygen are supposed to be drawn in enormous quantities toward the polar surfaces of the sun; during their gradual approach, they will pass from their condition of extreme attenuation and extreme cold to that of compression, accompanied with rise of temperature, until, on approaching the photosphere, they burst into flame, giving rise to a great development of heat, and a temperature commensurate with their point of dissociation at the solar density. The result of their combustion will be aqueous vapor, and carbonic anhydride or oxide, according to the sufficiency or insufficiency of oxygen present to complete the combustion; and these products of combustion, in yielding to the influence of centrifugal force, will flow toward the solar equator and be thence projected into space.

The next question for consideration is: What would become of these products of combustion when thus rendered back into space? Apparently they would gradually change the condition of stellar material, rendering it more and more neutral; but I venture to suggest the possibility, nay, the probability, that solar radiation would, under these circumstances, step in to bring back the combined materials to a condition of separation by a process of dissociation carried into effect at the expense of that solar energy which is now supposed to be lost to our planetary system.

According to the law of dissociation, as developed by Bunsen and Sainte-Claire Deville, the point of dissociation of different compounds depends upon the temperature on the one hand, and upon the pressure on the other. According to Sainte-Claire Deville, the dissociation tension of aqueous vapor of atmospheric pressure and at 2,800° C. is 0·5, or only half of the vapor can exist as such, its remaining half being found as a mechanical mixture of hydrogen and oxygen, but that with the pressure, the temperature of dissociation rises and falls, as the temperature of saturated steam rises and falls with its pressure. It is therefore conceivable that the temperature of the solar photosphere may be raised by combustion to a temperature exceeding 2,800° C., whereas dissociation may be effected in space at a lower temperature.

But these investigations had reference only to heats measured by means of pyrometers, but do not extend to the effects of radiant heat. Dr Tyndall has shown by his exhaustive researches that vapor of water and other gaseous compounds intercept radiant heat in a most remarkable degree, and there is other evidence to show that radiant energy from a source of high intensity possesses a dissociating power far surpassing the measurable temperature to which the compound substance under its influence is raised. Thus carbonic anhydride and water are dissociated in the leaf cells of plants, under the influence of the direct solar ray at ordinary summer temperature, and experiments, in which I have been engaged for nearly three years,* go to prove that this dissociating action is obtained also under the radiant influence of the electric arc, although it is scarcely perceptible if the source of radiant energy is such as can be produced by the combustion of oil or gas.

The point of dissociation of aqueous vapor and carbonic anhydride admits, however, of being determined by direct experiment. It engaged my attention some years ago, but I have hesitated to publish the qualitative results I then obtained, in the hope of attaining to quantitative proofs.

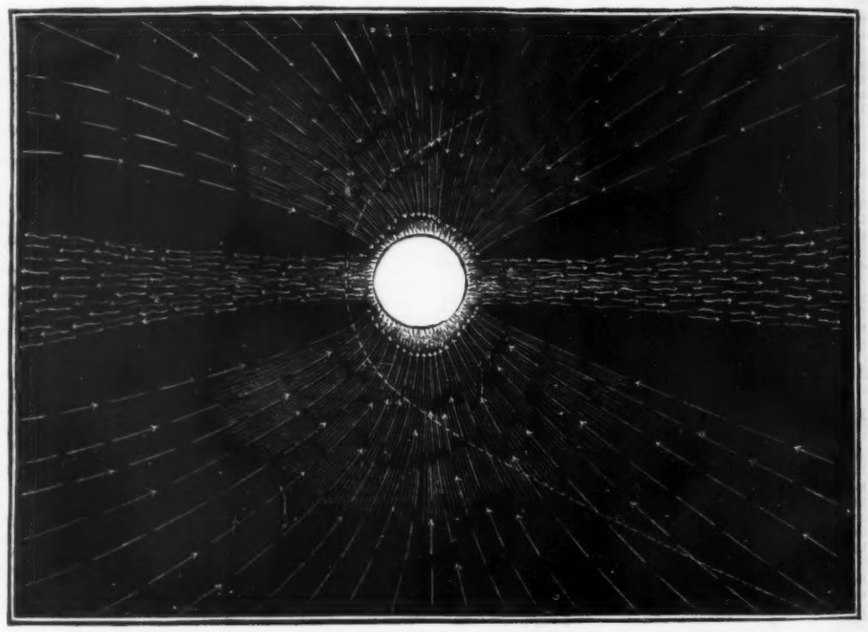
These experiments consisted in the employment of glass tubes, furnished with platinum electrodes, and filled with aqueous vapor, or with carbonic anhydride in the usual manner, the latter being furnished with caustic soda to regulate the vapor pressure by heating. Upon immersing one end of the tube charged with aqueous vapor in a refrigerating mixture of ice and chloride of calcium, its temperature at the end was reduced to 22° C., corresponding to a vapor pressure, according to Regnault, of 1-1800 of an atmosphere. When so cooled no slow electric discharge took place on connecting the two electrodes with a small induction coil. I then exposed the end of the tube projecting out of the freezing mixture, backed by white paper, to solar radiation (on a clear summer's day) for several hours, when upon again connecting up to the inductorium, a discharge, apparently that of a hydrogen vacuum, was obtained. This experiment being repeated furnished unmistakable evidence, I thought, that aqueous vapor had been dissociated by exposure to solar radiation. The CO_2 tubes gave, however, less reliable results. Not satisfied with these qualitative results, I made arrangements to collect the permanent gases so produced by means of a Sprengel pump, but was prevented by lack of time from pursuing the inquiry, which I purpose, however, to resume shortly, being of opinion that, independently of my present speculation, the experiments may prove useful in extending our knowledge regarding the laws of dissociation.

Assuming, for my present purpose, that dissociation of aqueous vapors was really effected in the experiment just described, and assuming, further, that stellar space is filled with aqueous and other vapor of a density not exceeding the 1-2000th part of our atmosphere, it seems reasonable to suppose that its dissociation would be effected by solar radiation, and that solar energy would thus be utilized. The presence of carbonic anhydride and carbonic oxide would only serve to facilitate the decomposition of the aqueous vapor by furnishing substances to combine with nascent oxygen and hydrogen. By means of the fan-like action resulting from the rotation of the sun, the vapor dissociated in space to-day would be drawn toward the polar surfaces of the sun to-morrow, be heated by increase in density, and would burst into flame at a point where both their density and temperature had reached the necessary elevation to induce combustion, each complete cycle taking, however, years to be accomplished. The resulting aqueous vapor, carbonic anhydride and carbonic oxide, would be drawn toward the equatorial regions, and be then again projected into space by centrifugal force.

Space would, according to these views, be filled with gaseous compounds in process of decomposition by solar radiant energy, and the existence of these gases would furnish an explanation of the solar absorption spectrum, in which the lines of some of the substances may be entirely neutralized and lost to observation. As regards the heavy metallic vapors revealed in the sun by the spectroscope, it is assumed that these form a lower and denser solar atmosphere, not participating in the fan-like action which is supposed to effect the light outer atmosphere only, in which hydrogen is the principal factor.

Such a dense metallic atmosphere could not participate in the fan action affecting the lighter photosphere, because this is only feasible on the supposition that the density of the in-flowing current is, at equal distances from the gravitating center, equal or nearly equal to the outflowing current. It is true that the products of combustion of hydrogen and carbonic oxide are denser than their constituents, but this difference may be balanced by their superior temperature on leaving the sun, whereas the metallic vapors would be unbalanced, and would therefore obey the laws of gravitation, recalling them to the sun. On the surface of contact between the two solar atmospheres, intermixture induced by friction must take place, however, giving rise perhaps to those vortices and explosive effects which are revealed to us by the telescope, and have been commented on by Sir John Herschel and other astronomers. Some of the denser vapors would probably get intermixed and carried away mechanically by the lighter gases, and give rise to that cosmic dust which is observed to fall upon our earth in not inappreciable quantities; excessive intermixture would be prevented by the intermediary neutral atmosphere, the penumbra.

As the whole solar system moves through space at a pace estimated at 150,000,000 of miles annually (being about one-fourth of the velocity of the earth in its orbit), it appears possible that the condition of the gaseous fuel supplying the sun may vary according to its state of previous decomposition, in which other heavenly bodies may have taken part. May it not be owing to such differences in the quality of the fuel supplied that the observed variations of the solar heat may depend? and may it not be in consequence of such changes in the thermal condition of the photosphere that sun-spots are formed?



The views here advocated could not be thought acceptable unless they furnished at any rate a consistent explanation of the still somewhat mysterious phenomena of the zodiacal light and of comets. Regarding the former, we should be able to return to Mairan's views, the objection by La Place being met by a continuous outward flow from the solar equator. Luminosity would be attributable to particles of dust emitting light reflected from the sun, or by phosphorescence. But there is another cause for luminosity of these particles, which may deserve a passing consideration. Each particle would be electrified by gaseous friction in its acceleration, and its electric tension would be vastly increased in its forcible removal, in the same way as the fine dust of the desert has been observed by Werner Siemens to be in a state of high electrification on the apex of the Cheops Pyramid. Would not the zodiacal light also find explanation by slow electric discharge backward from the dust toward the sun? and would the same cause not account for a great difference of potential between the sun and earth, which latter may be supposed to be washed by the solar radial current? May not the presence of the current also furnish us with an explanation of the fact that hydrogen, while abounding apparently in space, is practically absent in our atmosphere, where aqueous vapor, which may be partly derived from the sun, takes its place? An action analogous to this, though on a much smaller scale, may be set up also by terrestrial rotation giving rise to an electrical discharge from the outgoing equatorial stream to the polar regions, where the atmosphere to be pierced by the return flood is of least resistance.

It is also important to show how the phenomena of comets could be harmonized with the views here advocated, and I venture to hope that these occasional visitors will serve to furnish us with positive evidence in my favor. Astronomical physicists tell us that the nucleus of a comet consists of an aggregation of stones similar to meteoric stones. Adopting this view, and assuming that the stones have absorbed in stellar space gases to the amount of six times their volume, taken at atmospheric pressure, what, it may be asked, will be the effect of such a mass of stone ad-

* See Proceedings Roy. Soc., vol. xxx., 1 March, 1880, and a paper read before Section A of the British Association 1 Sept., 1881, and ordered to be printed in the Report.

vancing toward the sun at a velocity reaching in perihelion the prodigious rate of 366 miles per second (as observed in the comet of 1845), being twenty-three times our orbital rate of motion? It appears evident that the entry of such a divided mass into a comparatively dense atmosphere must be accompanied by a rise of temperature by frictional resistance, aided by attractive condensation. At a certain point the increase of temperature must cause ignition, and the heat thus produced must drive out the occluded gases, which in an atmosphere 3,000 times less dense than that of our earth would produce 6×3,000=18,000 times the volume of the stones themselves. These gases would issue forth in all directions, but would remain unobserved except in that of motion, in which they would meet the interplanetary atmosphere with the compound velocity and form a zone of intense combustion, such as Dr. Huggins has lately observed to surround the one side of nucleus, evidently the side of forward motion. The nucleus would thus emit original light, whereas the tail may be supposed to consist of stellar dust rendered luminous by reflex action produced by the light of the sun and comet combined, as foreshadowed already by Tyndall, Tate, and others, starting each from different assumptions.

These are in brief the outlines of my reflections regarding this most fascinating question which I venture to put before the Royal Society. Although I cannot pretend to an intimate acquaintance with the more intricate phenomena of solar physics, I have long had a conviction, derived principally from familiarity with some of the terrestrial effects of heat, that the prodigious and seemingly wanton dissipation of solar heat is unnecessary to satisfy accepted principles regarding the conservation of energy, but that it may be arrested and returned over and over again to the sun, in a manner somewhat analogous to the action of the heat recuperator in the regenerative gas furnace. The fundamental conditions are:

1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That these dissociated vapors are capable of being compressed into the solar photosphere by a process of interchange with an equal amount of reassociated vapors, this interchange being effected by the centrifugal action of the sun itself.

If these conditions could be substantiated, we should gain the satisfaction that our solar system would no longer impress us with the idea of prodigious waste through dissipation of energy into space, but rather with that of well-ordered self-sustaining action, capable of perpetuating solar radiation to the remotest future.

THE SALMON DISEASE.*

FOR some years an epidemic disease, followed by a very large number of deaths, has been observed to prevail among the salmon of certain Scottish and British rivers, from the Tay, on the north, as far as the Conway on the south.

The first obvious symptom of the malady is the appearance of one or more whitish patches upon the skin of parts of the body which are not covered with scales, such as the top and sides of the head, the adipose fin, and the soft skin at the bases of the other fins.

Such a patch, when it first attracts attention, may be as big as a sixpence. It is nearly circular, with a well-defined margin, and a somewhat raised softer center, from which faint ridges radiate toward the circumference. It is important to observe that a single small patch of this kind may be seen on the skin of a fish which, in all other respects, is perfectly healthy, and when there is no indication that the skin has ever been bruised or abraded in the place occupied by the patch. The patch, once formed, rapidly increases in size, and becomes confluent with any other patches which may have appeared in its neighborhood. The marginal area, as it extends over the adjacent healthy skin, retains its character; but the central part undergoes an important change. It takes on the consistency of wet paper, and can be lifted up in soft flakes, as if it were a slough, from the surface of the derma or true skin, which it covers. In fact, it is obvious that this papyraceous substance has taken the place of the epidermis, so that the sensitive and vascular true skin is deprived of its natural protection. As the patch spreads, the true skin beneath the central papyraceous slough ulcerates and an open bleeding sore is formed, which may extend down to the bone, while it passes outward into burrowing sinuses.

When the disease has reached this stage it obviously causes great irritation. The fish dash about and rub themselves against stones, and thus in all probability aggravate the evils under which they suffer. One vast open sore may cover the top of the head from the snout to the nape, and may extend over the gill covers. The edges of the fins become ragged; and, sometimes, the skin which invests them is so completely frayed away that the fin-rays stand out separately.

Although the affection of the skin appears, usually, if not invariably, to commence in the scaleless parts of the body, it does not stop there, but gradually spreads over the whole of the back and sides of the fish, though I have not yet seen a specimen in which it covered the whole ventral surface. The disease extends into the mouth, especially affecting the delicate valvular membrane attached to the inner side of the upper and the lower jaws. It is said to attack the gills, but there has been no sign of it on these organs in any fish which I have had the opportunity of examining.

Fish which succumb to the disease become weak and sluggish, seeking the shallows near the banks of the river, where they finally die.

The flesh of a salmon affected by this disease presents no difference in texture or color from that of a healthy fish; and those who have made the experiment declare that the flavor is just as good in the former case as in the latter. So far as my observations have gone the viscera may be perfectly healthy in the most extensively diseased fish; and there is no abnormal appearance in the blood.

It is known that a disease similar to that described is occasionally prevalent among salmon in North America and in Siberia; and I do not see any ground for the supposition that it is a novelty in British rivers. But public attention was first directed to it in consequence of its ravages in the Solway district a few years ago; and, in 1878, a commission was appointed to inquire into the subject.

The evidence taken by the commissioners leaves no room for doubt that the malady is to be assigned to the large and constantly increasing class of diseases which are caused by parasitic organisms. It is a contagious and infectious disease of the same order as ringworm in the human subject, mascardine among silkworms, or the potato disease among plants; and, like them, is the work of a minute fungus. In fact, the *Saprolegnia* which is the cause of the salmon disease is an organism in all respects very closely allied to the *Peronospora*, which is the cause of the potato disease.

It is a very curious circumstance, however, that while the *Peronosporæ* are always parasites—that is to say, depend altogether upon living plants for their support—the *Saprolegniæ* are essentially saprophytes; that is to say, they ordinarily derive their nourishment from dead animal and vegetable matters, and are only occasionally parasites upon living organisms. In this respect they resemble the *Bacteria*, if the results of recent researches, which tend to show that pathogenic bacteria are mere modifications of saprogenic forms, are to be accepted.

As I have said, I do not think that the evidence laid before the commission of 1878 can leave any doubt as to the causation of the salmon disease on the minds of those who are acquainted with the history of the analogous diseases in other animals and in plants. Nevertheless, this evidence, valuable as it is, suggests more questions than it answers, and in November, 1881, hearing that the disease had broken out in the Conway, I addressed myself to the attempt to answer some of these.

It was already known that when the papyraceous slough-like substance which coats the skin of a diseased salmon is subjected to microscopic examination, it is found to be a *mycelium*, or fungus-turf, composed of a felt-work of fine tubular filaments or *hyphæ*, many of which are terminated by elongated oval enlargements, or *zoosporangia*. Within these the protoplasm breaks up into numerous spheroidal particles, each less than one two-thousandth of an inch in diameter. These, the *zoospores*, are set free through an opening formed at the apex of the zoosporangium, and become actively or passively dispersed through the surrounding water. Herein lies the source of the contagiousness or infectiousness of the disease. For any one of these zoospores, reaching a part of the healthy skin of the same or of another salmon, germinates and soon gives rise to a mycelium similar to that from which it started.

But I could find no satisfactory information as to the manner in which the fungus enters the skin, how far it penetrates, the exact nature of the mischief which it does, or what ultimately becomes of it; nor was the identity of the pathogenic *Saprolegnia* of the salmon with that of any known form of saprogenic *Saprolegnia* demonstrated. It appeared to me, however, to be useless to attempt to deal with the disease until some of these important elements of the question were determined.

To this end, in the first place, I made a careful examination of the minute structure of both the healthy and diseased skin, properly hardened and cut into thin sections; and, in the second place, I tried some experiments on the transplantation of the *Saprolegnia* of the living salmon to dead animal bodies. Perhaps it will conduce to intelligibility if I narrate the results of the latter observation first.

The body of a recently killed common house-fly was gently rubbed two or three times over the surface of a patch of the diseased skin of a salmon, and was then placed in a vessel of water, on the surface of which it floated, in consequence of the large quantity of air which a fly's body contains. In the course of forty-eight hours, or thereabouts, innumerable white cottony filaments made their appearance, set close side by side, and radiated from the body of the fly in all directions. As these filaments had approximately the same length, the fly's body thus became inclosed in a thick white spheroidal shroud, having a diameter of as much as half an inch. As the filaments are specifically heavier than water, they gradually overcome the buoyancy of the air contained in the tracheæ of the fly, and the whole mass sinks to the bottom of the vessel. The filaments are very short when they are first discernible, and usually make their appearance where the integument of the fly is softest, as between the head and thorax, upon the proboscis, and between the rings of the abdomen. These filaments, in their size, their structure, and the manner in which they give rise to zoosporangia and zoospores are precisely similar to the hyphæ of the salmon fungus; and the characters of the one, as of the other, prove that the fungus is a *Saprolegnia* and not an *Achlya*. Moreover, it is easy to obtain evidence that the body of the fly has become infected by spores swept off by its surface when it was rubbed over the diseased salmon skin. These spores have in fact germinated, and their hyphæ have perforated the cuticle of the fly, notwithstanding its comparative density, and have been ramified outward and inward, growing at the expense of the nourishment supplied by the tissues of the fly.

This experiment, which has been repeated with all needful checks, proves that the pathogenic *Saprolegnia* of the living salmon may become an ordinary saprogenic *Saprolegnia*; and, *per contra*, that the latter may give rise to the former; and they lead to the important practical conclusion that the cause of salmon disease may exist in all waters in which dead insects, infested with *Saprolegniæ*, are met with; that is to say, probably in all the fresh waters of these islands, at one time or another.

On the other hand, *Saprolegnia* has never been observed on decaying bodies in salt water, and there is every reason to believe that, as a saprophyte, it is confined to fresh waters.*

Thus it becomes, to say the least, a highly probable conclusion that we must look for the origin of the disease to the *Saprolegniæ* which infest dead organic bodies in our fresh waters. Neither pollution, drought, nor overstocking will produce the disease if the *Saprolegnia* is absent. The most these conditions can do is to favor the development or the diffusion of the *materies morbi* where the *Saprolegnia* already exists.

Having infected dead flies with the salmon *Saprolegnia*, once from Conway and once from Tweed fish, I was enabled to propagate it from these flies to other flies, and, in this manner, to set up a sort of garden of *Saprolegniæ*. And having got thus far, I fancied it would be an easy task to determine the exact species of the *Saprolegnia* with which I was dealing, from the abundant data furnished by the works of Pringsheim, De Bary, and others, who have so fully studied these plants when cultivated on the same materials. For this purpose, it was necessary to obtain the oosporangia; and in ordinary course, these should have made their appearance on my *Saprolegnia* in five or six days. Unfortunately, in the course of cultivation, continued over two months, nothing of the kind has taken place. Zoosporangia have abounded in the ordinary form and also in that known as "dictyosporangia," but, in no instance, have any oosporangia appeared. After a few days of vigorous growth, the zoosporangia become scanty, and the fungus takes on a torulose form, segments of the hyphæ becoming swollen and then detached as independent "gemmæ," which may germinate. Sometimes the gemmæ are spheroidal and terminal, and closely simulate oosporangia.

Although, therefore, I have very little doubt that the *Saprolegnia* of the salmon is one of the forms of the "*S. ferax* group" of Pringsheim and De Bary, I have, at present, no proof of the fact.

Another very curious and unexpected peculiarity of the salmon *Saprolegnia*, both on the fish and when transmitted to flies, so far as my observations have hitherto gone, is that locomotive ciliated zoospores do not occur. I once saw one which exhibited a very slight motion for a few minutes after it left the zoosporangium; but although thousands must have passed under my notice, with the exception to which I have referred, they have always been perfectly quiescent and not unfrequently in different stages of germination. Whether the season of the year, or the conditions under which my saprolegnized flies were placed, have anything to do with the non-appearance of oosporangia and of locomotive zoospores in them I cannot say. But it is certain that the *Saprolegnia ferax*, which commonly appears upon dead flies and other insects, normally develops both oosporangia and locomotive zoospores in abundance.

From such notices by other observers as I can gather, oosporangia appear to be of very rare occurrence in the *Saprolegnia* of the salmon itself. Mr. Stirling mentions that he has met with them only four times. With respect to locomotive zoospores, I can find no positive evidence that they have been regularly, or even frequently, observed in the salmon *Saprolegnia*. But these points require careful investigation on freshly taken diseased fish.

Whether the zoospores are actively locomotive or not, they are quite free when they emerge from the zoosporangia; and, from their extreme minuteness, they must be readily carried away and diffused through the surrounding water. Hence, a salmon entering a stream inhabited by the *Saprolegnia* will be exposed to the chance of coming into contact with *Saprolegnia* spores; and the probability of infection, other things being alike, will be in proportion to the quantity of the growing *Saprolegnia*, and the vigor with which the process of spore-formation is carried on. At a very moderate estimate, a single fly may bear 1,000 fruiting hyphæ; and if each sporangium contains twenty zoospores, and runs through the whole course of its development in twelve hours, the result will be the production of 40,000 zoospores in a day, which is more than enough to furnish one zoospore to the cubic inch of twenty cubic feet of water. Even if we halve this rate of production, it is easy to see that the *Saprolegnia* on a single fly might furnish spores enough to render such a small shallow stream as salmon often ascend for spawning purposes, dangerous for several days. But a large fully diseased salmon may have as much as two square feet of its skin thickly covered with *Saprolegnia*. If we allow only 1,000 fruiting hyphæ for every square inch, we shall have 288,000 for the whole surface, which, at the same rate as before, gives over 10,000,000 spores for a day's production, or enough to provide a spore to every cubic foot of a mass of water 100 feet wide and five feet deep and four miles long. Forty such diseased salmon might furnish one spore to the gallon for all the water of the Thames (380,000,000 gallons per diem) which flows over Tedington Weir. But two thousand diseased salmon have been taken out of a single comparatively insignificant river in the course of a season.

It will be understood that the above numerical estimate of the productivity of *Saprolegnia* has been adopted merely for the sake of illustration; that I do not intend to suggest that the zoospores are evenly distributed through the water into which they are discharged by the zoosporangia; and that allowance must be made for the very short life of those zoospores which do not speedily reach an appropriate nidus. Nevertheless, the conclusion remains arithmetically certain that every diseased salmon adds immensely to the chances of infection of those which are not diseased; and thus, the policy of extirpating every diseased fish as soon as possible has ample justification. But, in practice, the attempt to stamp out the disease in this fashion would be so costly that it may be a question whether it is not better to put up with the loss caused by the malady.

There are many practical difficulties in the way of directly observing the manner in which the zoospores effect their entrance into the skin of the fish; but, on comparing the structure of the healthy integument with that of the diseased patches, the manner of the operation can readily be divined. The skin of the head of a salmon, for example, presents a thin superficial cellular epidermis covering the deep fibrous and vascular derma. The epidermic cells are distinguishable, as in fishes in general, into a deep, a middle and a superficial layer. In the first, the cells are vertically elongated, in the second more rounded and polygonal, in the third flattened. Many of the cells of the middle layer are of the nature of "mucous cells." They enlarge and become filled with a mucous secretion; and, rising to the surface, burst and discharge their contents, which give rise to the mucous fluid with which the fish's body is covered. The openings of these "mucous cells" remain patent for some time, and are to be seen in thin vertical sections. The hyphæ of the spores which attach themselves to the fish may enter by these openings, but even if they do not, the flattened superficial cells certainly offer no greater resistance than does the tough cuticle of a fly. However this may be, sections of young patches of diseased skin show that the hyphæ of the fungus not only traverse the epidermis, but bore through the superficial layer of the derma for a distance, in some cases, of as much as one-tenth of an inch. Each hypha thus comes to have a stem part, which lies in the epidermis, and a root part, which lies in the derma. Each of these elongates and branches out. The free ends of the stem-hyphæ rise above the surface of the epidermis and become converted into zoosporangia, more or fewer of the spores of which attach themselves to the surrounding epidermis and repeat the process of penetration. Thus the epidermis and the derma become traversed by numerous hyphæ set close side by side. But, at the same time, these hyphæ send off lateral branches which spread radially, forcing asunder the middle and deeper layers of the epidermic cells, and giving rise to the radiating ridges which are visible to the naked eye in the peripheral part of the patch. The force of the growth of the hyphæ which traverse the epidermis, is made obvious by the curious manner in which, when the central tract of a patch is teased out, the distorted epidermis cells are seen adhering to it as if they were spitted upon it.

In the derma, the root-hyphæ branch out, pierce the bundles of connective tissue, and usually end in curiously distorted extremities.

* A contribution to the pathology of the epidemic known as the Salmon Disease." Paper read at the Royal Society, March 2, by Prof. T. H. Huxley, LL.D., F.R.S.

* So far as I know there is only one case on record of the appearance of a fungus on a fish in salt water, and in this case it is not certain that the fungus was a *Saprolegnia*.

The effect of the growth of the stem-hyphæ is to destroy the epidermis altogether. Its place is taken by a thick, felted mycelium, which entangles the minute particles of sand which are suspended in the water, and thus no doubt constitutes a very irritating application to the sensitive surface of the true skin.

In the true skin, the tracks of the root-hyphæ are not accompanied by any obvious signs of inflammation, but the hyphæ are so close set, that they cannot fail to interfere with the nutrition of the part, and thus bring about necrosis and sloughing. Such sloughing in fact gradually takes place, small vessels give way and bleed, and the burrowing sore, which is characteristic of the advanced stages of the disease, is produced.

The skin of the head may thus be eaten away down to the bone and gristle of the skull, but I have not observed the fungus to enter these. On the scaly part of the skin, the fungus burrows in the superficial and in the deep layer of the pouches of the scales, but I have not observed the scales themselves to be perforated.

When I found that the fungus penetrated the true skin, and thus gained access to the lymphatic spaces and blood-vessels, it became a matter of great interest to ascertain whether the hyphæ might not break up into turuloid segments (as in the case of the *Empusa musca*), and thus give rise to general septic poisoning, or fungoid metastasis. However, I have never been able to find any indication of the occurrence of such a process.

But a very important practical question arises out of the discovery that the fungus penetrates into the derma. There is much reason to believe that if a diseased salmon returns to salt water, all the fungus which is reached by the saline fluid is killed, and the destroyed epidermis is repaired. But the sea water has no access to the hyphæ which have burrowed into the true skin; and hence it must be admitted to be possible, that, in a salmon which has become to all appearance healed in the sea, and which looks perfectly healthy when it ascends a river, the remains of the fungus in the derma may break out from within, and the fish become diseased without any fresh infection. It has not infrequently been observed, that salmon in their upward course became diseased at a surprisingly short distance from the sea, and it is possible that the explanation of the fact is to be sought in the revival of dormant *Saprolegnia*, rather than in new infection. It is to be hoped, that experiments, now being carried on at Berwick, will throw some light on this point, as well as upon the asserted efficacy of sea water in destroying the fungus which it reaches.

These are the chief results of this season's observations on the salmon disease. Incomplete as they are, they appear to me to justify the following conclusions:

1. That the *Saprolegnia* attacks the healthy living salmon exactly in the same way as it attacks the dead insect, and that it is the sole cause of the disease, whatever circumstances may, in a secondary manner, assist its operations.

2. That death may result without any other organ than the skin being attacked, and that, under these circumstances, it is the consequence partly of the exhaustion of nervous energy by the incessant irritation of the felted mycelium with its charge of fine sand, and partly of the drain of nutriment appropriated by the fungus.

3. That the penetration of the hyphæ of the *Saprolegnia* into the derma renders it at least possible that the disease may break out in a fresh-run salmon without reinfection.

4. That the cause of the disease, the *Saprolegnia*, may flourish in any fresh water, in the absence of salmon, as a saprophyte upon dead insects and other animals.

5. That the chances of infection for a healthy fish entering a river, are prodigiously increased by the existence of diseased fish in that river, inasmuch as the bulk of *Saprolegnia* on a few diseased fish vastly exceeds that which would exist without them.

6. That as in the case of the potato disease, the careful extirpation of every diseased individual is the treatment theoretically indicated; though, in practice, it may not be worth while to adopt the treatment.

[Continued from SUPPLEMENT 328, page 5226.]

THE PHILOSOPHY OF ANIMAL COLORS.

By DR. ANDREW WILSON, F.R.S.E.

So far there seems nothing unusual or striking in a group of butterflies being protected, through strong odor and worse taste, from their natural enemies, the birds. But now comes the most curious phase of this history. Another and distinct family of butterflies, known as the *Leptalida*, allied to the common white cabbage butterfly, and removed from the Helicons, also possesses representatives in South America. There are no points of agreement between the Leptalidæ and the Helicons, save, indeed, that both are butterflies. Furthermore, the Leptalides are entirely destitute of the nauseous odor and of the strong taste of the Helicons, and in respect of their more agreeable presence, should become a prominent article—as do other butterflies—in the bill of fare of the birds. Yet, strangely enough, the Leptilides escape persecution; and the reason is not far to seek or difficult to find. When they are carefully examined, certain species of the Leptalides are seen to be exact *facsimiles*, in color and appearance, of the stinking Helicons! Naturalists at first classed both as Helicons, until a closer examination showed the difference between these butterflies, and likewise proved that the Leptalides had thus "mimicked" in the plainest possible manner the colors of their strong smelling neighbors. Nor are the colors alone imitated. The very shape of the Helicon's wings is reproduced in those of the Leptalides, and the "feelers" likewise mimic those of the former group. Again, special forms of Leptalides "mimic" special forms of Helicons. The flight has become of similar character in both species, and the habits have been also slavishly copied.

Such instances as these certainly present "food for thought" to the reflective mind. It is the business of philosophy to account for facts by placing the facts in scientific juxtaposition—philosophy, in this light, is the thread upon which the pearls of knowledge are strung. What, then, it may be asked, is the philosophy which can explain the curious resemblances seen in the animal world, ranging from, say, a mere likeness in tint to the surroundings (as in the flounder or woodcock), through more intensified likenesses, to the exact "mimicry" and to the slavish copy of color and form, as in the butterflies?

A first and highly important feature in the consideration of the case is found in the fact that there is a gradation in the degree of "mimicry." From the mere sand or ground tinting of the flounder to the exact coloring of the butterflies is, of course, a wide step, but it is one which is bridged over by intermediate examples and stages. Then, secondly, we discover a purpose or use in the disguises: that purpose, apart from any considerations of its origin, being the protection of the animal from its enemies, and the consequent good and increase of its race. Thirdly, it appears possible to account for these curious transformations and disguises, by finding an *initial* step. It is the old story of *le premier pas qui coûte*, applied to natural history research; and this first step is found in the solid axiom, that every living species is liable to *variation* and change. Next succeeds the consideration that such varieties as are produced have to "struggle for existence." Suppose a number of white varieties produced in a cold, snowy region, along with varieties of more conspicuous colors. It is evident that, while the white varieties would escape from their enemies, the darker colored individuals would succumb. Thus the white race comes to the front, and holds its own, and its perpetuation and increase becomes a matter of surety. Summing up the argument, we find that two factors are at work in bringing about these wonderful color likenesses in the animal world. The one is variation, producing the color varieties; the other is the circumstances of life, which weed out the weak and give the battle to the strong, which latter are those whose colors best suit their surroundings. This is the philosophy which natural history to-day lays down for our acceptance. Nay, more, it is a philosophy which explains far more important facts of life than mere mimicry. It is "evolution and development" reduced to their plainest and fundamental terms—in a word, Darwinism in a nutshell, as illustrated by the variation and change that all life knows, and by the warring of that life bringing the best of its units to the front of the battle.

HORTICULTURAL ITEMS.

Cultivation of Orchards.—Irving D. Cook, an extensive and successful orchardist near Batavia, N. Y., gives to the *Rural Home* his mode of culture, the substance of which is the following: For several years, while the trees are young, cultivate annually with some hoed crop, with manure, which will cause a free growth and give good crops from the soil. When the trees attain bearing age, summer fallow the off year, when the absence of a heavy crop will allow teams to pass under the lower branches, and sow to winter rye, with clover in the spring. Use the grass for sheep or swine pasture, top-dressing as required with yard manure by spreading it over the whole surface.

Washing the Bark.—We have always regarded good cultivation as more important than washing the bark of fruit trees with lime, soap, or potash, and that one reason why trees which are washed grow better than others is because those who take the pains to wash the bark take better care in other ways. Nevertheless, the washing of the bark may benefit the trees to a certain extent, at the same time that the appearance will be improved. If lime is used, it should be so thinly mixed with water as not to form a crust or to give a white coating to the bark. Potash should be so weak as not to corrode the bark of young trees. One of the best applications, however, appears to be a solution of aloes in warm water, which readily destroys the insects and their eggs in the bark.

Apples for Exportation.—Some English fruit dealers have published lists of the best apples to raise in this country for the English markets, and which succeed best for transatlantic conveyance. Among those which do best are named the Baldwin, Fallawater, Golden Russet, Greening, Lady Apple, Maiden's Blush, Pomme Grise, and Wagener. Northern Spy and Swaar must be large to sell well; Ribston Pippin and Tompkins' King must not be sent ripe; Seeknofurther sells well only when high colored; and Newtown Pippin, if large and fair, commands high prices, but if small and spotted will not bring even low prices. The following do not succeed well: Gravenstein, Fall Pippin, and Pound Sweet. Spitzenburgh decays soon when ripe.

Transplanting.—The question is asked if it makes any difference whether the same side of a tree is set to the north as it stood in the nursery. In answer, we may state that abundant experience shows that no difference whatever occurs, however the tree may be set, if it is only a few years old; but in removing old trees, which have stood for many years, the same side should be set to the sun as before. The bark on the north side having for a long time remained in the shade, will not always bear the sun's rays so well as the side which has been long inured to them, and sometimes, not always, the shaded bark is injured, blackened, or killed by the sudden exposure. It is not often that such large trees are removed, but when they are it is safest to preserve the same points of the compass.

Yellows of the Peach.—An article which has appeared in some of our exchanges, credited to the *American Naturalist*, repeats the opinion that a thin and poor soil contributes mainly to the prevalence of the yellows in peach trees. This is doubtless true in some instances, but, as in other cases and with other theories of tree diseases, facts frequently come in and seriously interfere. We have seen many trees affected and destroyed by the yellows within the past half century, some on poor soil and many on strong and rich soil, and one of the worst cases of this disease which we have seen was in a beautiful thirty acre peach orchard, the soil of which was naturally strong and rich, and was highly cultivated. We shall have to modify some of our theories.

California Raisins.—G. G. Briggs, of Yolo County, California, widely known for his extensive fruit plantations, writes to the *Rural New-Yorker* some account of his success and failures, showing that experience is required for success in any business. He planted a forty-acre vineyard in 1868, grafting the wild vines with the best European varieties. In 1872 he had more fruit than he could sell, and made a few raisins. In 1873 he shipped grapes east and got nothing for them, paying $1,000 freight, and losing labor, boxes, and grapes. In 1874 he gathered them all for raisins, and lost 160,000 pounds by rain, saving only those which were under cover. From 1875 to 1881 the quantity of raisins made increased every year from 160,000 to 1,000,000 pounds, and as indicating that he was not losing money, his vineyards had increased every year until amounting to over 900 acres. The raisins the past year, according to the figures he has given, must have sold for about $25,000, and they have about paid for the expenses of production and for the care of his young vines not yet in bearing, 500 acres of which he planted in 1880. He thinks raisin making will pay, if economically managed. His entire crop of fruit of all kinds sold the past year for about $100,000, and his expenses have about balanced them. The grapes for raisins are dried in shallow boxes, those which ripen at the end of August drying in fifteen days, and those a month later requiring more than twice that time.

Apples in Massachusetts.—At one of the meetings of the Massachusetts Horticultural Society, E. W. Wood, chairman of the fruit committee, said that the sorts which answered best for exportation were Gravenstein, Hubbardston, Nonsuch, Rhode Island Greening, Baldwin and Roxbury Russet, and these five sorts were also best for the home market. John B. Moore said the Gravenstein was universally popular. The Hubbardston was also very popular, and unlike the Baldwin would grow anywhere. The Rhode Island greening and Roxbury Russet needed a clay soil. Mr. Hayes, president of the society, said that one of the largest dealers in Boston recommended three-fourths Baldwins, with Gravensteins next; but he finally concluded it would be best to plant all Baldwins.

Avoid Hand Weeding.—Crops which are planted in beds or drills require a large amount of manual labor, unless on ground free from the seeds of weeds. A successful cultivator of the strawberry says it will pay well to devote the season previous to setting out a plantation to thoroughly summer-fallowing the ground, going over it every time with the plow, cultivator, or harrow, before the weeds can get above the surface. This work is done rapidly and cheaply with horses; but if omitted a vast amount of unpleasant work must be performed the next season by hand. This management will apply to other crops, such as carrots, turnips, etc.

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